



**ЗБОРНИК АПСТРАКТА И ПРОГРАМ  
65. КОНФЕРЕНЦИЈЕ ЕТРАН и 8. КОНФЕРЕНЦИЈЕ ИцЕТРАН**

**Proceedings of Abstracts and Program  
8<sup>th</sup> Conference IcETRAN in conjunction  
with the 65<sup>th</sup> ETRAN Conference**

Етно село Станишићи, Република Српска, 8 - 10. септембра 2021. године  
Ethno Village Stanišići, Republic of Srpska, 8 - 10, September, 2021



Електроника  
Телекомуникације  
Рачунарство  
Аутоматика  
Нуклеарна техника

# **ЗБОРНИК АПСТРАКТА И ПРОГРАМ**

**65. КОНФЕРЕНЦИЈЕ ЕТРАН**

Етно село Станишићи,  
Република Српска  
8 - 10. септембар 2021. године

Београд, август 2021.



## **Поштовани учесници 65. конференције ЕТРАН-а и 8. конференције ИцЕТРАН-а**

Друштво за ЕТРАН, као једну од најважнијих активности, организује годишње састанке који треба да допринесу социјализацији младих који се баве истраживањем и иновацијама. Нестабилност на економском нивоу и промене система вредности које су карактерисале Србију претходних година су оставиле последице и на рад Друштва за ЕТРАН. Ентузијазам Етрановаца на територији Србије је донео резултате и ЕТРАН је успео да се консолидује.

Вирус који нас је упозорио на укупну осетљивост света на непредвиђено је значајно уназидо могућност да наставимо истим путем. Прошле, 2020. године смо успели да организујемо конференцију у дистрибуираној форми на неколико локација и у четири града. Ове 2021. године организујемо састанак у Етно селу Станишићи, у Републици Србији. Повећање страха од заразе и реална опасност од проширења популације заражених вирусом КОВИД-19 је утицала да се смањи број пријављених, иако су конференције планиране да буду хибридне, прецизније да постоје in-vivo презентације, а да постоји опција учествовања online.

На конференцијама ЕТРАН 2021 и ИцЕТРАН 2021 ће бити преко 150 радова, шест позваних предавања, три специјалне седнице посвећене Електроенергетици у 21. веку, ограничењима која постоје у рачунарству у овом тренутку, и политици преласка на дигиталне технологије у Србији и Републици Српској. Посветићемо две седнице сећању на академика Нинослава Стојадиновића и др Милољуба Смиљанића који су у дугом периоду били стубови Друштва за ЕТРАН.


На Скупштини Друштва за ЕТРАН, која је планирана за септембар 2021. године ћемо размотрите неке организационе промене у броју и доменима појединих стручних секција и почети процес промена Статута Друштва.

На Скупштини ћемо редефинисати задатке усвојене на Скупштини 2016. године: развој сарадње са Привредном комором Србије да би ЕТРАН постао део тима за изградњу стратегије научног и технолошког развоја Србије; развој и стварање партнерства са државним и приватним компанијама које су у областима деловања Друштва за ЕТРАН; организација специјализованих међународних састанака; и повећању препознатљивости резултата који се саопштавају на годишњим конференцијама Друштва ЕТРАН-а кроз укључења радова у Зборнику у одговарајуће базе података.

Верујем да су конференције у Етно селу Станишићи у периоду од 8. до 10. септембра 2021, важан корак у реализацији постављених циљева.

Желим свим учесницима да буду здрави и успешни у својим жељама и намерама да глобално поправе квалитет живота и замене израз забринутости на лицима осмесица.

Ваш Председник ЕТРАН-а



Дејан Поповић

Београд, 2021.



**ЕТРАН - Друштво за електронику, телекомуникације, рачунарство, аутоматику  
и нуклеарну технику**

Кнеза Милоша 9/IV, 11000 Београд  
Tel. 011 3233 957, E-mail: office@etran.rs, www.etran.rs

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### **ОРГАНИЗАТОРИ**

Друштво за ЕТРАН

Универзитет у Београду – Електротехнички факултет, Београд, Србија

Универзитет у Бањој Луци – Електротехнички факултет, Бања Лука, Босна и Херцеговина

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### **ПОКРОВИТЕЉ**

Министарство просвете, науке и технолошког развоја републике Србије

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### **ПОДРШКА**

IEEE – Institute of Electrical and Electronics Engineers, USA

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### **Друштво за ЕТРАН**

#### **Председник**

Проф. др Дејан Б. Поповић

*Академик САНУ, Београд (Србија)*

#### **Потпредседник**

Проф. др Слободан Вукосавић,

*дописни члан САНУ, Електротехнички факултет, Београд (Србија)*

## НАУЧНИ ОДБОР КОНФЕРЕНЦИЈЕ ЕТРАН 2021

### КОПРЕДСЕДНИЦИ

Проф. Бранко Докић, Бања Лука, Република Српска

Проф. Мило Томашевић, Београд, Србија

### ЧЛАНОВИ

Проф. Емилија Амброзини, Милано, Италија

Проф. Карстен Бернс, Кајзерслаутерн, Немачка

Проф. Винсент Боне, Париз, Француска

Проф. Ђурађ Будимир, Лондон, Велика Британија

Проф. Сања Вранеш, Београд, Србија

Дописни члан САНУ Слободан Вукосавић, Београд, Србија

Проф. Пасквале Дапонте, Санија, Италија

Проф. Рафаел Дима, Лион, Француска

Проф. Страхинја Дошен, Алборг, Данска

Академик САНУ Антоније Ђорђевић, Београд, Србија

Академик ЦАНУ Игор Ђуровић, Подгорица, Црна Гора

Проф. Жељко Ђуровић, Београд, Србија

Проф. Драган Манчић, Ниш, Србија

Научни саветник Зоран Јакшић, Београд, Србија

Проф. Ђорђе Јанаћковић, Београд, Србија

Дописни члан САНУ Бранислав Јеленковић, Београд, Србија

Проф. Никола Јорговановић, Нови Сад, Србија

Проф. Хелен Караца, Солун, Грчка

Проф. Владимир Катић, Нови Сад, Србија

Проф. Зора Коњовић, Нови Сад, Србија

Проф. Мирослав Крстић, Сан Дијего, Калифорнија, САД

Проф. Јозеф Лацко, Будимпешта, Мађарска

Проф. Емил Леви, Ливерпул, Велика Британија

Проф. Христос Мадемлис, Солун, Грчка

Проф. Гвидо Мајоне, Бари, Италија

Проф. Теодор Лаопулос, Солун, Грчка

Научни сарадник Небојша Малешевић, Лунд, Шведска

Научни саветник Бранко Матовић, Београд, Србија

Проф. Миомир Мијић, Београд, Србија

Проф. Братислав Миловановић, Ниш, Србија

Проф. Драган Денић, Ниш, Србија

Проф. Небојша Митровић, Чачак, Србија

Научни сарадник Драгана Николић, Београд, Србија

Проф. Албена Паскалева, Софија, Бугарска

Проф. Предраг Петковић, Ниш, Србија

Академик Зоран Љ. Петровић, Београд, Србија

Научни саветник Предраг Петровић, Београд, Србија

Проф. Алесандро Пизано, Каљари, Италија

Академик САНУ Дејан Поповић, Београд, Србија  
Академик САНУ Зоран Поповић, Београд, Србија  
Проф. Р. Е. Прокуп, Темишвар, Румунија  
Проф. Вељко Поткоњак, Београд, Србија  
Дописни члан САНУ Велимир Радмиловић, Београд, Србија  
Проф. Бранимир Рељин, Београд  
Проф. Данијела Ристић-Дурант, Бремен, Немачка  
Проф. Роман Серизел, Нанси, Француска  
Проф. Пол Сотириадис, Атина, Грчка  
Проф. Владимир Срдих, Нови Сад, Србија  
Проф. Срђан Станковић, Београд, Србија  
Проф. Србијанака Турајлић, Београд, Србија  
Проф. Петар Ускоковић, Београд, Србија  
Проф. Овидиу Флорин, Јаши, Румунија  
Проф. Франц Цотер, Грац, Аустрија

## **ОДБОР ЗА НАУЧНЕ И СТРУЧНЕ СКУПОВЕ ЕТРАН 2021**

### **КОПРЕДСЕДНИЦИ ОРГАНИЗАЦИОНОГ ОДБОРА**

Др Зоран Ђурић, Универзитет Бања Лука  
Др Божидар Поповић, Универзитет Источно Сарајево  
Др Мило Томашевић, Електротехнички факултет, Универзитет у Београду

### **ЧЛАНОВИ ОРГАНИЗАЦИОНОГ ОДБОРА**

Др Лазар Сарановац, Електротехнички факултет, Универзитет у Београду  
Др Марко Димитријевић, Електронски факултет, Универзитет у Нишу  
Др Александра Смиљанић, Електротехнички факултет, Универзитет у Београду  
Др Ненад Милошевић, Електронски факултет, Универзитет у Нишу  
Др Петар Спалевић, Факултет техничких наука, Универзитет у Косовској Митровици  
Др Иван Милентијевић, Електронски факултет, Универзитет у Нишу  
Др Игор Тартаља, Електротехнички факултет, Универзитет у Београду  
Др Милан Рапаић, Факултет техничких наука, Универзитет у Новом Саду  
Др Бобан Веселић, Електронски факултет, Универзитет у Нишу  
Др Ковиљка Станковић, Електротехнички факултет, Универзитет у Београду  
Др Драган Брајовић, Факултет техничких наука, Универзитет у Крагујевцу  
Др Дејан Ђирић, Електронски факултет, Универзитет у Нишу  
Др Миодраг Тасић, Електротехнички факултет, Универзитет у Београду  
Др Милица Јанковић, Електротехнички факултет, Универзитет у Београду  
Др Милан Милосављевић, Сингидунум Универзитет, Београд  
Др Марко Росић, Факултет техничких наука, Универзитет у Крагујевцу  
Др Платон Совиљ, Факултет техничких наука, Универзитет у Новом Саду  
Др Анета Пријић, Електронски факултет, Универзитет у Нишу  
Др Небојша Дончов, Електронски факултет, Универзитет у Нишу  
Др Весна Пауновић, Електронски факултет, Универзитет у Нишу  
Др Александар Родић, Институт “Михајло Пупин”, Београд

Др Владимир Рисојевић, Универзитет Бања Лука  
Др Петар Матић, Универзитет Бања Лука  
Др Татјана Пешић Брђанин, Универзитет Бања Лука  
Др Зоран Ђурић, Универзитет Бања Лука

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## **Подршка промоцији награђених радова**

**Проф. др Милић Ђекић**

*Факултет техничких наука, Чачак*

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## **Локални организациони одбор**

Буловић Јовица, *Универзитет Бања Лука*  
Кнежић Младен, *Универзитет Бања Лука*  
Дикић Б. Петар, *Универзитет Бања Лука*

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## **Програмска и техничка подршка**

Мирјана Јованић, стручни сарадник, *Друштво за ЕТРАН*  
Златко Јарневић, стручни сарадник, *Друштво за ЕТРАН*

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## **Техничка и маркетиншка подршка**

Марко Вујадиновић, *Академска мисао, Београд (Србија)*  
Александар Рашковић, *Академска мисао, Београд (Србија)*  
Бобан Милијић, *Академска мисао, Београд (Србија)*

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## **Лица одговорна за сајт**

Душан Никезић, *Институт Винча, Београд (Србија)*  
Узахир Рамадани, *Институт Винча, Београд (Србија)*

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## **Деск за регистрацију**

**Деск за регистрацију се отвара у Четвртак 7. септембра у 16 сати:**

**Радно време Деска:**

<b>Четвртак 7. септембар 2021.</b>	<b>16:00 - 18:00</b>
<b>Среда, 8. септембар 2019.</b>	<b>10:00 – 12:30 и 15:00 – 17:30</b>
<b>Четвртак, 9. септембар 2021.</b>	<b>10:00 – 13:30 и 15:00 – 17:30</b>
<b>Петак, 10. септембар 2021.</b>	<b>10:00 – 13:30 и 15:00 – 17:30</b>



## Колективни чланови ЕТРАН-а

1. Електротехнички факултет, Београд
2. Електронски факултет, Ниш
3. Факултет техничких наука, Нови Сад
4. Факултет техничких наука, Чачак
5. Факултет организационих наука, Београд
6. Електротехнички факултет, Бања Лука
7. Електротехнички факултет, Подгорица
8. Електротехнички факултет, Источно Сарајево
9. Саобраћајни факултет, Београд
10. Технолошко металуршки факултет, Београд
11. Универзитет Сингидунум, Београд
12. Универзитет Метрополитан, Београд
13. Институт Ирител а.д, Београд
14. Институт Михајло Пупин, Београд
15. Институт Никола Тесла, Београд
16. Институт техничких наука САНУ, Београд
17. ИМТЕЛ Комуникација, Београд
18. Иновациони центар Електротехничког факултета, Београд
19. Иновациони центар напредних технологија, Ниш
20. РТ-РК, Нови Сад
21. РАТЕЛ, Београд
22. Висока школа струковних студија за информационе и комуникационе технологије, Београд
23. Висока школа електротехнике и рачунарства струковних студија, Београд
24. Влатаком, Београд

Скраћенице:

	IcETРАН	ЕТРАН
Електроника	ELI	EL
Телекомуникације	TEI	TE
Рачунарство	RTI	RT
Аутоматика	AUI	AU
Нуклеарна техника	NTI	NT
Акустика	AKI	AK
Антене и простирање	API	AP
Вештачка интелигенција	VII	VI
Електрична кола, електрични системи и обрада сигнала	EEI	EE
Електроенергетика	EKI	EK
Биомедицинска техника	BTI	BT
Метрологија	MLI	ML
Нови материјали	MOI	MO
Микроелектроника и оптоелектроника	MTI	MT
Микроталасна техника, технологије и системи	NMI	NM
Роботика и флексибилна аутоматизација	ROI	RO

## Распоред дешавања на 65. Конференцији ЕТРАН

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*Среда, 8. септембар 2021 у 09:00 (Сала 3)*

### Специјална седница на секцији МЕТРОЛОГИЈА

**„Стохастичке методе у мерењима”**

координатор Владимир Вујичић

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*Среда, 8. септембар 2021 у 11:45 (Сала 1)*

### Заједничка тематска седница на конференцијама ЕТРАН 2021 и ИцЕТРАН 2021

**„Дигитална Србија и Република Српска”**

координатори Бранко Докић и Мило Томашевић

Учесници:

Мр Срђан Рајчевић,

*министар за научнотехнолошки развој, високо образовање  
и информационо друштво у Влади Републике Српске;*

Проф. др Зоран Ђурић,

*декан Електротехничког факултета Универзитета у Бањој Луци;*

Др Михаило Јовановић,

*директор Канцеларије за ИТ и електронску управу Владе Србије;*

Др Саша Стојановић,

*помоћник министра за просвјету, науку и технолошки развој Владе Србије.*

#### **Кратки садржај**

Дигитална трансформација привреде и читаве економије је глобално препозната као основни чинилац бржег друштвено-економског развоја и раста бруто-домаћег производа, па је и Влада Србије уврстила дигитализацију као један од приоритета у наредном периоду што је наглашено у усвојеним стратегијама и акционим плановима. Основни предуслов за овај процес је подстицање техничко-технолошког развоја, а посебно интензиван развој информационо-комуникационих технологија, као и унапређење дигиталне инфраструктуре. Примена дигиталних технологија у свакодневном животу и значај дигиталних сервиса за олакшање пословања привреде и грађана се поготово показао важним у време актуелне пандемије и представља смерницу за будуће деловање. Проактиван утицај државе на овај сектор и стварање подстицајног пословног окружења је од великог значаја поготово што се тиче улагања у инфраструктуру и постављања одговарајућег правно-регулаторног оквира. Пропагација иновативних решења као и изградња стартап еко-система су такође веома значајни чиниоци. Један од основа концепта дигитализације је и унапређење информатичког образовања да би се обезбедили неопходни кадрови, а то захтева улагања у реформу и услове рада образовног система. Иако су улагања у информационо-комуникационе технологије на овим просторима тренутно доста мања од европског просека, почетни резултати и трендови у расту овог сектора и учешћу у извозу су евидентни и охрабрујући, а потенцијали за даља унапређења евидентни.

Сектор информационо-комуникационих технологија у Републици Српској има константан раст последњих неколико година, а који се јасно види у све већем броју компанија и броју запослених у области информационо-комуникационих технологија. Република Српска активно ради на питању дигиталне трансформације, при чему Влада Републике Српске дигиталну трансформацију види као велику развојну шансу и као један од најважнијих приоритета у наредном периоду. Са Републиком Србијом прошле године потписан је и Споразум о сарадњи у области дигиталне трансформације, чији је основни циљ да се позитивна искуства и знања из Републике Србије у овој области подијеле са Републиком Српском.

Република Српска већ неколико година ради на успостављању одговарајућег правно-регулаторног оквира који треба још више да подстакне развој сектора информационо-комуникационих технологија. Бројне су активности у току, као и пројекти у фази реализације, а који за циљ имају постављање основа за развој дигиталног друштва. Поред тога, у посљедње вријеме изражена је и

већа подршка формалном образовању у области информационо-комуникационих технологија које је под директном ингеренцијом Министарства за научно-технолошки развој, високо образовање и информационо друштво Републике Српске.

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Среда, 8. септембар 2021. 12:45-13:30, Сала 1

**СВЕЧАНО ОТВАРАЊЕ**

Проф. др Дејан Поповић: **Уводне напомене**

**Коктел добродошлице**

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Среда, 8. септембар 2021. у 18:45 (Сала 1)

**Заједничка тематска седница на конференцијама ЕТРАН 2021 и ИцЕТРАН 2021**

**„ОМАЖ МИЛОЉУБУ СМИЉАНИЋУ“**

Координатор: Предраг М. Петровић

Напустио нас је Милољуб (Мића) Смиљанић

*Генерални секретар Академије инжењерских наука Србије (АИНС)  
и Почасни члан Друштва за ЕТРАН.*

**„Драги Мићо, дивљење и поштовање са захвалношћу!“**

Позвана обраћања:

Дејан Б. Поповић, Председник ЕТРАН-а

Зоран Ђурић, Академик САНУ и АИНС

Бранко Ковачевић, Председник АИНС

Братислав Миловановић, Академик АИНС

---

Четвртак, 9. септембар 2021 у 11:15 (сала 1)

**Специјална седница на секцији РАЧУНАРСТВО И ВЕШТАЧКА ИНТЕЛИГЕНЦИЈА**

**„Шта рачунари данас не могу ”**

координатор Бошко Николић

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Четвртак, 9. септембар 2021 у 12:45 (сала 1)

**Заједничка тематска седница на конференцијама ЕТРАН 2021 и ИцЕТРАН 2021**

**„ОМАЖ НИНОСЛАВУ СТОЈАДИНОВИЋУ“**

Координатор: Дејан Б. Поповић

Напустио нас је Нинослав Стојадиновић

*бивши Председник, члан Председништва и Заслужни члан Друштва за ЕТРАН.*

**„Остајемо да негујемо његове идеје!“**

Обраћања:

Слободан Вукосавић:

**„Приказ научног рада и инжењерски доприноси Нинослава Стојадиновића,  
Председника Огранка САНУ у Нишу“**

Данијел Данковић:

**„Активности академика и председника огранка САНУ у Нишу Нинослава  
Стојадиновића на Електронском факултету, Универзитету у Нишу  
и Огранку САНУ у Нишу“**

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*Четвртак, 9. септембар 2021 у 18:45 (сала 1)*  
**СКУПШТИНА ДРУШТВА ЗА ЕТРАН**

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*Четвртак, 9. септембар 2021 у 20:00*  
**СВЕЧАНА ВЕЧЕРА**

---

*Петак, 10. септембар 2021 у 16:30*  
**Специјална седница на секцији ЕЛЕКТРОЕНЕРГЕТИКА**  
**„Електроенергетика у XXI веку ”**  
координатор Слободан Вукосавић, Одбор за енергетику САНУ

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*Петак, 10. септембар 2021 у 18:45*  
**НЕФОРМАЛНО ЗАТВАРАЊЕ КОНФЕРЕНЦИЈА ЕТРАН 2021 И ИЦЕТРАН 2021**

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Electronics  
Telecommunication  
Computers  
Automations  
Nuclear Technique

## **Program and Abstracts**

8<sup>th</sup> International Conference on Electrical,  
Electronic and Computing Engineering

**IcETRAN 2021**

In conjunction with the 65<sup>th</sup> annual meeting  
of ETRAN Society

Etno willage Stanišići,  
Republic of Srpska, Bosnia and Herzegovina  
September 8 - 10, 2021

Belgrade, August 2021



## Dear participants of the 65<sup>th</sup> ETRAN and the 8<sup>th</sup> IcETLAN Conferences,

The ETRAN Society, as one of the essential activities, organizes annual meetings that should contribute to the socialization of young people engaged in research and innovation. The instability at the economic level and the changes in the value system that have characterized Serbia in previous years left consequences on the work of the ETRAN Association. The enthusiasm of the people of ETRAN on the territory of Serbia brought results, and ETRAN managed to consolidate.

The corona virus that warned us about the overall sensitivity of the world to the unforeseen has significantly set back the ability to continue on the same path. Last year, in 2020, we organized a conference in a distributed form at several locations and in four cities. This year, 2021, we are organizing a meeting in the Ethno Village Stanišići, in the Republic of Serbia. Increased fear of infection and the real danger of expanding the population infected with the KOVID-19 virus have reduced the number of applicants. However, conferences are planned to be hybrid, more precisely to have in-vivo presentations and the option to participate online.

The Conferences ETRAN 2021 and IcETLAN 2021 include over 150 papers, six invited lectures, three special sessions dedicated to Power Engineering in the 21st century, the limitations in computing methodologies entering our lives, and the policy of transition to digital technologies in Serbia and the Republic Srpska. We are dedicating two sessions to the memory of academician Ninoslav Stojadinović and Dr. Miloljub Smiljanić, who were the pillars of the Society for ETRAN for a long time.

At the Assembly of the Company for ETRAN, which is planned for September 2021, we will consider some organizational changes in the number and domains of individual professional sections and begin changing the Statute of the Association. At the Assembly, we will redefine the tasks adopted at the Assembly in 2016: development of cooperation with the Serbian Chamber of Commerce so that ETRAN becomes part of the team for building a strategy for scientific and technological development of Serbia; development and creation of partnerships with state and private companies that are in the areas of activity of the Company for ETRAN; organization of specialized international meetings; and increasing the visibility of the results that are announced at the annual conferences of the ETRAN Society through the inclusion of papers in the Proceedings in the relevant databases.

I believe that the conferences in the Ethno Village Stanišići, from September 8 to 10, 2021, are an essential step in realizing the set goals.

I wish all participants to be healthy and prosperous in their desires and intentions to globally improve the quality of life and replace the expression of concern on the faces by smiles.

President of ETRAN



Dejan Popović

Belgrade, 2021.





## **IcET|TRAN – International Conference on Electrical, Electronic and Computing Engineering**

Kneza Miloša 9/IV, 11000 Belgrade, Serbia

Phone: +381 11 3233 957, E-mail: [office@etran.rs](mailto:office@etran.rs), <https://www.etran.rs>

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### **Organizers**

ET|TRAN Society, Belgrade

University of Banja Luka - Faculty of Electrical Engineering, Banja Luka, Bosnia and Herzegovina

University of Belgrade – School of Electrical Engineering, Belgrade, Serbia

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### **Under the auspices of**

Ministry of Education, Science and Technological Development of the Republic of Serbia

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### **With the support of**

IEEE – Institute of Electrical and Electronics Engineers, USA

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## **SCIENTIFIC COMMITTEE ICET|TRAN 2021**

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Prof. Milo Tomašević, Belgrade, Serbia

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### **CO-CHAIRS OF THE ORGANIZING COMMITTEE**

Dr. Zoran Đurić, University of Banja Luka - Faculty of Electrical Engineering  
 Dr. Božidar Popović, University of East Sarajevo - Faculty of Electrical Engineering  
 Dr. Milo Tomašević, University of Belgrade - School of Electrical Engineering

### **MEMBERS**

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Dr. Tatjana Pešić Brđanin, University of Banja Luka  
Dr. Zoran Đurić, University of Banja Luka

### **Support to promotion of the awarded papers**

**Prof. Milić Đekić**

*Faculty of Technical Sciences, Čačak (Serbia)*

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### **Local Organizing Committee of IcETRAN 2018**

Bulović Jovica, *University of Banja Luka*

Knežić Mladen, *University of Banja Luka*

Dikić B. Petar, *University of Banja Luka*

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### **Program and Technical support**

Mirjana Jovanić, *ETRAN*

Zlatko Jarnević, *ETRAN*

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### **Program and Technical support**

Marko Vujadinović, *Academic Mind, Belgrade*

Aleksandar Rašković, *Academic mind, Belgrade*

Boban Milijić, *Academic mind, Belgrade*

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### **The persons responsible for the site**

Dušan Nikezić, *Institute Vinča, Belgrade (Serbia)*

Uzahir Ramadani, *Institute Vinča, Belgrade (Serbia)*

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## Conference Desk

**The registration desk of the IcETRAN conference will operate:**

<b>Tuesday, September 7, 2021</b>	<b>16:00 – 18:00</b>
<b>Wednesday, September 8, 2021</b>	<b>10:00 – 12:30 &amp; 15:00 – 17:30</b>
<b>Thursday, September 9, 2021</b>	<b>10:00 – 13:30 &amp; 15:00 – 17:30</b>
<b>Friday, September 10, 2021</b>	<b>10:00 – 13:30 &amp; 15:00 – 17:30</b>

## Corporate members of ETRAN Society

1. College of vocational studies of Electrical Engineering and Computers, Belgrade
2. Faculty of Technical Sciences Čačak, University of Kragujevac (FTS Čačak)
3. ICT College of vocational studies, Belgrade
4. IMTEL Institute, Belgrade
5. Innovation Center of Advanced Technologies, Niš (ICAT Niš)
6. Innovation Center of School of Electrical Engineering, Belgrade
7. Institute of Technical Sciences of SASA, Belgrade
8. Iritel a.d., Belgrade
9. Metropolitan University, Belgrade
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11. Nikola Tesla Institute, Belgrade
12. RATEL, Belgrade
13. RT-RK, Novi Sad
14. School of Electrical Engineering, East Sarajevo
15. Singidunum University, Belgrade
16. University of Banja Luka, Faculty of Electrical Engineering (FEE Banja Luka)
17. University of Belgrade, Faculty of Organizational Sciences
18. University of Belgrade, Faculty of Technology and Metallurgy
19. University of Belgrade, Faculty of Transport and Traffic Engineering, Belgrade
20. University of Belgrade, School of Electrical Engineering, University of Belgrade (SEE Belgrade)
21. University of Niš, Faculty of Electronic Engineering (FEE Niš)
22. University of Novi Sad, Faculty of Technical Sciences (FTS Novi Sad)
23. University of Podgorica, Faculty of Electrical Engineering (FEE Podgorica), Montenegro
24. Vlatakom Innovation Centre, Belgrade

Acronyms	International	National
Electronics	ELI	EL
Telecommunications	TEI	TE
Computing and information engineering	RTI	RT
Automation	AUI	AU
Nuclear engineering and technology	NTI	NT
Acoustics	AKI	AK
Antennas and propagation	API	AP
Artificial intelligence	VII	VI
Power engineering	EEI	EE
Electric circuits and systems and signal processing	EKI	EK
Biomedical engineering	BTI	BT
Metrology	MLI	ML
Microelectronics and optoelectronics	MOI	MO
Microwave technique, technologies and systems	MTI	MT
New materials in electrical and electronic engineering	NMI	NM
Robotics and flexible automation	ROI	RO

## **IcETRAN Events Program**

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*Wednesday, September 8, 9:00 (Room 3)*

### **Special Session at the Section METROLOGY „Stochastic Methods in Measurements”,**

Coordinator Vladimir Vujičić

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*Wednesday, September 8, 11:45 (Room 1)*

### **Joint Thematic Session at ETRAN 2021/IcETRAN2021 Conferences “Digital Serbia and Republic of Serbia”**

Coordinators Branko Dokić and Milo Tomašević

Participants:

Mr Srđan Rajčević

*Minister of the Ministry of Scientific and Technological Development, Higher Education  
and Information Society of the Republic of Srpska*

Prof. Dr Zoran Đurić

*Dean of the Faculty of Electrical Engineering, University of Banja Luka*

Dr Mihajlo Jovanović

*Director of the Office for Information Technologies and eGovernment of the Republic of Serbia*

Dr Saša Stojanović

*Assistant Minister of the Ministry of Education, Science and Technological Development  
of the Republic of Serbia*

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*Wednesday, September 8, 12:45 (Room 1)*

### **CONFERENCE OPENING**

Prof. Dr Dejan B. Popović: **Opening remarks**

**Welcome cocktail**

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*Wednesday, September 8, 18:45 (Room 1)*

### **Joint Thematic Session at ETRAN 2021/IcETRAN2021 Conferences “Homage to Miloljub Smiljanić”**

Coordinator Predrag Petrović

Miloljub (Mića) Smiljanić, left us

*the Secretary-General of the Academy of Engineering Sciences of Serbia (AINS)  
and the Honorary Member of the Society for ETRAN.*

**„Dear Mićo, admiration, and respect with gratitude!”**

Invited addresses:

Dejan B. Popović, President of ETRAN

Zoran Đurić, Academician of SANU and AINS

Branko Kovačević, President of AINS

Bratislav Milovanović, Academician of AINS

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*Thursday, September 9, 11:45 (Room 1)*

**Special Session at the Sections COMPUTING AND INFORMATION ENGINEERING  
and ARTIFICIAL INTELIGENCE  
„What computers can't do today”,**

Coordinator Boško Nikolić

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*Thursday, September 9, 12:45 (Room 1)*

**Joint Thematic Session at ETRAN 2021/IcETTRAN2021 Conferences  
“Homage to Ninoslav Stojadinović”**

Coordinator Dejan B. Popović

Ninoslav Stojadinović, left us

*Former President, member of the Presidency and Honored Member.*

**„We will continue to nurture his ideas!”**

Participants:

Slobodan Vukosavić

**Review of scientific work and engineering contributions  
of the late Prof. Ninoslav Stojadinović, member of SASA.**

Danijel Danković:

**Activities of Prof. Ninoslav Stojadinović, member of SASA,  
President of the branch of SASA in Niš at the Faculty of Electronics,  
University of Niš and Branch of SANU in Niš.**

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*Thursday, September 9, 18:45 (Room 1)*

**GENERAL ASSEMBLY OF THE ETRAN SOCIETY**

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*Thursday, September 9, 20:00*

**GALA DINER**

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*Friday, September 10, 11:45 (Room 1)*

**Special Session at the Section POWER ENGINEERING  
„Power Engineering in the XXI century”,**

Coordinator Slobodan Vukosavić, SASA

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*Friday, September 10, 18:45*

**CONFERENCE CLOSING**

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### **ANTENNAS AND PROPAGATION/ ANTENE I PROSTIRANJE (AP) 4**

#### **SESSION/SESIJA API1+AP1 4**

WEDNESDAY/SREDA, SEPTEMBER/SEPTEMBAR, 08<sup>TH</sup>, 16:15 – 17:00, ROOM 1/SOBA 1 4

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WEDNESDAY/SREDA, SEPTEMBER/SEPTEMBAR, 08<sup>TH</sup>, 15:00 – 17:00, ROOM 2/SOBA 2 5

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FRIDAY/PETAK, SEPTEMBER/SEPTEMBAR, 10<sup>TH</sup>, 17:15 – 18:45, ROOM 2/SOBA 2 14

### **ELECTRIC CIRCUITS AND SYSTEMS, AND SIGNAL PROCESSING/ ELEKTRIČNA KOLA, ELEKTRIČNI SISTEMI I OBRADA SIGNALA (EK) 16**

#### **SESSION/SESIJA EKI1+EK1 16**

WEDNESDAY/SREDA, SEPTEMBER/SEPTEMBAR, 08<sup>TH</sup>, 15:00 – 15:30, ROOM 3/SOBA 3 16



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**ELECTRONICS/ ELEKTRONIKA (EL)**

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**17****SESSION/SESIJA ELI 1****17**

THURSDAY/ČETVRTAK, SEPTEMBER/SEPTEMBAR, 09<sup>TH</sup>, 15:00 – 17:00, ROOM 3/SOBA 3 17

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**METROLOGY/ METROLOGIJA (ML)**

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**19****SESSION/SESIJA ML1****19**

THURSDAY/ČETVRTAK, SEPTEMBER/SEPTEMBAR, 09<sup>TH</sup>, 09:00 – 11:30, ROOM 2/SOBA 2 19

**SESSION/SESIJA ML2****21**

THURSDAY/ČETVRTAK, SEPTEMBER/SEPTEMBAR, 09<sup>TH</sup>, 15:00 – 17:00, ROOM 2/SOBA 2 21

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**MICROELECTRONICS AND OPTOELECTRONICS, NANOSCIENCES AND NANOTECHNOLOGIES/**

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**MIKROELEKTRONIKA I OPTOELEKTRONIKA (MO)**

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**24****SESSION/SESIJA MOI1****24**

WEDNESDAY/SREDA, SEPTEMBER/SEPTEMBAR, 08<sup>TH</sup>, 15:30 – 17:00, ROOM 3/SOBA 3 24

**SESSION/SESIJA MO1****26**

WEDNESDAY/SREDA, SEPTEMBER/SEPTEMBAR, 08<sup>TH</sup>, 17:15 – 18:45, ROOM 3/SOBA 3 26

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**MICROWAVE TECHNIQUE, TECHNOLOGIES AND SYSTEMS/**

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**MIKROTALASNA TEHNIKA, TEHNOLOGIJE I SISTEMI (MT)**

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**28****SESSION/SESIJA MTI1****28**

WEDNESDAY/SREDA, SEPTEMBER/SEPTEMBAR, 08<sup>TH</sup>, 15:00 – 16:15, ROOM 1/SOBA 1 28

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**NEW MATERIALS IN ELECTRICAL AND ELECTRONIC ENGINEERING/**

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**NOVI MATERIJALI (NM)**

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**30****SESSION/SESIJA NMI1****30**

FRIDAY/PETAK, SEPTEMBER/SEPTEMBAR, 10<sup>TH</sup>, 09:00 – 11:30, ROOM 2/SOBA 2 30

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**NUCLEAR ENGINEERING AND TECHNOLOGY/**

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**NUKLEARNA TEHNIKA (NT)**

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**34****SESSION/SESIJA NTI1+NT1****34**

THURSDAY/ČETVRTAK, SEPTEMBER/SEPTEMBAR, 09<sup>TH</sup>, 09:00 – 11:30, ROOM 3/SOBA 3 34

## **COMPUTING AND INFORMATION ENGINEERING/ RAČUNARSKA TEHNIKA I INFORMATIKA (RT)** **36**

### **SESSION/SESIJA RT11:** **36**

THURSDAY/ČETVRTAK, SEPTEMBER/SEPTEMBAR, 09<sup>TH</sup>, 09:00 – 11:30, ROOM 1/SOBA 1 36

### **SESSION/SESIJA RT12:** **39**

THURSDAY/ČETVRTAK, SEPTEMBER/SEPTEMBAR, 09<sup>TH</sup>, 15:00 – 17:00, ROOM 1/SOBA 1 39

### **SASSION/SESIJA RT1:** **41**

THURSDAY/ČETVRTAK, SEPTEMBER/SEPTEMBAR, 09<sup>TH</sup>, 17:15 – 18:45, ROOM 1/SOBA 1 41

## **ROBOTICS AND FLEXIBLE AUTOMATION/ ROBOTIKA I FLEKSIBILNA AUTOMATIZACIJA/(RO)** **43**

### **SESSION/SESIJA ROI1** **43**

FRIDAY/PETAK, SEPTEMBER/SEPTEMBAR, 10<sup>TH</sup>, 17:15 – 18:45, ROOM 1/SOBA 1 43

### **SESSION/SESIJA RO1+ROI2** **44**

FRIDAY/PETAK, SEPTEMBER/SEPTEMBAR, 10<sup>TH</sup>, 15:00 – 17:00, ROOM 1/SOBA 1 44

## **TELECOMMUNICATIONS/ TELEKOMUNIKACIJE (TE)** **47**

### **SESSION/SESIJA TE11+TE1** **47**

WEDNESDAY/SREDA, SEPTEMBER/SEPTEMBAR, 08<sup>TH</sup>, 09:00 – 11:30, ROOM 2/SOBA 2 47

## **ARTIFICIAL INTELLIGENCE/ VEŠTAČKA INTELIGENCIJA (VI)** **51**

### **SESSION/SESIJA: VII1 + VI1** **51**

WEDNESDAY/SREDA, SEPTEMBER/SEPTEMBAR, 08<sup>TH</sup>, 17:15 – 18:45, ROOM 1/SOBA 1 51

## **METROLOGY/ METROLOGIJA (ML)** **53**

### **SPECIAL SESSION: STOCHASTIC METHODS IN MEASUREMENT/ SPECIJALNA SESIJA: STOHAŠTIČKE METODE U MERENJIMA SS-ML1** **53**

WEDNESDAY/SREDA, SEPTEMBER/SEPTEMBAR, 08<sup>TH</sup>, 09:00 – 11:30, ROOM 3/SOBA 3 53



## **Acoustics/ Akustika (AK)**

### **SESSION/SESIJA AKI1+AK1**

Wednesday/Sreda, September/Septembar, 08<sup>th</sup>, 09:00 – 11:30, Room 1/Soba 1

#### **Chair/Predsedavajući:**

**Miomir Mijić, University of Belgrade, School of Electrical Engineering, Serbia**

**Dejan Ćirić, Faculty of Electronic Engineering, University of Niš, Serbia**

#### **AKI1.1 WHISPERED SPEECH RECOGNITION BASED ON DTW ALGORITHM AND $\mu$ FCC FEATURE**

*Branko R. Marković, Faculty of Technical Science Čačak, Serbia*

*Jovan Galić, Faculty of Electrical Engineering, Banja Luka, Bosnia and Herzegovina*

This paper presents the results of normal and whispered speech recognition using the  $\mu$ FCC ( $\mu$ -law Frequency Cepstral Coefficients) feature. This feature uses a warping frequency function and it is applied at the front-end of ASR. The Dynamic Time Warping algorithm is used at the back-end of the ASR system. All experiments were performed using the part of the Whi-Spe database. Four scenarios are analyzed: normal/normal, whisper/whisper, normal/whisper and whisper/normal in the speaker dependent mode. The results confirmed an expected improvement in recognition of whispered speech compared to the standard LFCC and MFCC features.

#### **AKI1.2 THE EXPERIMENTS IN SVM-BASED WHISPERING SPEAKER IDENTIFICATION**

*Jovan Galić, Faculty of Electrical Engineering, University of Banja Luka, Bosnia and Herzegovina*

*Branko Marković, Faculty of Technical Science Čačak, University of Kragujevac, Serbia*

*Dorđe Grozdić, Grid Dynamics Holdings, Inc, Serbia*

This paper presents results of automatic speaker recognition in normally phonated (neutral) and whispered speech, based on Support Vector Machines (SVM) and Whi-Spe speech database. The performance of the recognizer is examined in matched N/N (Neutral/Neutral) and W/W (Whispered/Whispered) train/test scenarios for different types of kernels (Radial basis function, Polynomial, Linear, and Sigmoid). The best accuracy is obtained with a polynomial kernel (96,12% for neutral speech and 92,16 in case of whispering). The influence of the size of training data on the performance of the recognizer is examined, as well.

#### **AKI1.3 CEPSTRUM-BASED PITCH DETECTION OF INDUSTRIAL PRODUCT SOUND**

*Dejan Ćirić, Faculty of Electronic Engineering in Niš, Niš, Serbia,*

*Marko Janković, Faculty of Electronic Engineering in Niš, Niš, Serbia,*

*Marko Milenković, Faculty of Arts, University of Niš, Niš, Serbia*

*Miljan Milić, Technical College of Applied Studies in Kragujevac, section in Kruševac, Serbia*

Various audio features can be extracted from audio signals. One of very important ones is pitch. Different algorithms and methods have been proposed in literature to detect pitch. Among them, cepstrum-based pitch detection as a frequency domain method has often been used in practice. Cepstrum is calculated as the inverse Fourier transform of the logarithm of signal spectrum. The fundamental frequency and pitch in this way is estimated as the maximum value of cepstrum in the defined segment. Here, pitch of some industrial products (compressors and DC motors) are estimated by applying the modified cepstrum-based algorithm. The detected pitch values can be used to make a distinction between different working conditions of these products such as different rotation-per-minute (rpm).

## AK1.1 KRITERIJUMI ZVUČNOG KOMFORA U PROSTORIJAMA ZA VEŽBANJE I IZVOĐENJE MUZIČKOG PROGRAMA

*Dragana Šumarac Pavlović, School of Electrical Engineering, Belgrade University, Serbia*

*Tatjana Miljković, Elektrotehnički fakultet Univerziteta u Beogradu, Serbia*

*Miloš Bjelić, School of Electrical Engineering, University of Belgrade, Serbia*

*Miomir Mijić, University of Belgrade, School of Electrical Engineering, Serbia*

Zvučni komfor u prostorima za vežbanje i izvođenje muzičkog programa definisan je kriterijumima iz tri domena: zvučne zaštite, kvaliteta zvučne slike i zaštite privatnosti. U ovim akustički osetljivim prostorima zvučni komfor se ne može regulisati opštim normativima iz više razloga. Radi se o prostorima u kojima se uobičajeno javljaju povišeni nivoi zvuka u prostorijama i istovremeno pooštreni kriterijumi za dozvoljene nivoje ambijentalne buke koja dospeva iz okruženja. U ovom radu dat je pregled različitih parametara koji se koriste u projektovanju ovakvih objekata, koji se oslanja na istraživanja, pre svega subjektivnih preferenci korisnika. Polazeći od spektralnih i dinamičkih karakteristika zvuka pojedinačnih muzičkih instrumenata i kriterijuma za zvučnu izolaciju i zaštitu privatnosti analizirani su mogući dometi zvučne zaštite prostora za vežbanje standardnim pregradnim konstrukcijama. Obzirom da je u planu izgradnja nove zgrade Fakulteta muzičke umetnosti u Beogradu, cilj ovog rada je pregled relevantnih standarda i principa koji se moraju poštovati u projektovanju da bi se u prostorima za muzičko obrazovanje ostvario zvučni komfor u svim njegovim aspektima.

## AK1.2 UTICAJ ESTIMACIJE FREKVENCIJA HARMONIKA NA PROCENU KOEFICIJENTA INHARMONIČNOSTI ČEMBALA

*Tatjana Miljković, Elektrotehnički fakultet Univerziteta u Beogradu, Serbia*

*Jovana Damjanović, Elektrotehnički fakultet Univerziteta u Beogradu, Serbia*

*Jelena Čertić, Univeristy of Belgrade, School of Electrical Engineering, Serbia*

*Dragana Šumarac Pavlović, School of Electrical Engineering, Belgrade University, Serbia*

Inharmoničnost je pojava koja se javlja kod žičanih instrumenata i predstavlja odstupanje frekvencija parcijala tona od celobrojnih umnožaka osnovne frekvencije tona. U prethodnom istraživačkom radu pokazano je da automatski algoritam za procenu koeficijenta inharmoničnosti tonova klavira za pojedine tonove iz registra ne vrši dobru estimaciju koeficijenta inharmoničnosti. U ovom radu razmatran je uticaj tačnosti procene frekvencija harmonika na procenu koeficijenta inharmoničnosti. Sprovedena je uporedna analiza dve metode za procenu spektra signala, i to procena spektra na osnovu AR modela i metodom DFT. Testiranje predloženih metoda za procenu spektra izvršeno je na realnim tonovima čembala. Ustanovljeno je da je na osnovu trenda koeficijenta inharmoničnosti računatog pomoću obe metode za procenu spektra, metoda AR modelom superiornija i vrši tačniju procenu koeficijenta inharmoničnosti na celom opsegu tonova od interesa.

## AK1.3 VREME REVERBERACIJE ENERGETSKOG TRANSFORMATORA

*Miloš Bjelić, Elektrotehnički fakultet, Univerzitet u Beogradu, Serbia*

*Bogdan Brković, Elektrotehnički fakultet, Univerzitet u Beogradu, Serbia*

*Mileta Žarković, Elektrotehnički fakultet, Univerzitet u Beogradu, Serbia*

*Tatjana Miljković, Elektrotehnički fakultet, Univerzitet u Beogradu, Serbia*

Energetski transformator je uz generator jedan od najvažnijih elemenata elektroenergetskih sistema. Pouzdanost rada energetskog transformatora direktno je povezana sa njegovim stanjem. Analiza rezultata ispitivanja svodi se na vizuelno poređenje frekvencijskih odziva periodičnih merenja transformatora, dobijenih pomoću specijalizovanih uređaja. Nedostatak ove metode je oslanjanje na inženjersko iskustvo. Objektivniji način detekcije kvarova je izračunavanje matematičkih indikatora zasnovanih na analizi frekvencijskog odziva. Ovi parametri često nisu u stanju da nedvosmisleno ukažu na stepen kvara. Ovaj rad predstavlja novi pristup za otkrivanje unutrašnjih kratkih spojeva transformatora. Predlaže se novi indikator zasnovan na vremenu reverberacije, koje se uobičajno koristi u akustici. Predloženi parametar zasnovan je na proračunu u vremenskom domenu i omogućava pouzdanu detekciju kratkih spojeva transformatora i tačnu procenu njihovog stepena.

#### AK1.4 ANALIZA UPOTREBLJIVOSTI EKONOMIČNOG AUDIO HARDVERA PRILIKOM SNIMANJA IMPULSNIH ODZIVA PROSTORIJE

*Marko Licanin, Faculty of occupational safety in Nis, Serbia*

*Dejan Ćirić, Faculty of Electronic Engineering, University of Niš, Serbia*

*Darko Mihajlov, Faculty of Occupational Safety, Serbia*

*Momir Prašćević, University of Nis, Faculty of Occupational Safety, Serbia*

Monitoring i analiza buke u životnoj sredini, prema trenutnim standardima i metodologijama zahteva korišćenje opreme visoke preciznosti čija cena može biti izuzetno visoka. Zbog toga je monitoringom teško pokriti šira područja gde je nivo buke potrebno pratiti u većem broju tačaka. Postavlja se pitanje da li je moguće vršiti monitoring koristeći ekonomičnija rešenja čime bi se povećao broj mernih lokacija. Prvi korak u analizi ovakvih rešenja je ispitivanje tehničkih karakteristika dostupnog hardvera koji se može iskoristiti u svrhu snimanja audio signala. Ubrzani razvoj mikro računara omogućio je njihovu integraciju u različitim projektima, gde oni služe kao centralne jedinice za obradu signala. Razvoj i unapređenje novih generacija senzora različitog tipa, imajući u vidu njihove niske cene na tržištu, omogućava praćenje velikog broja fizičkih i hemijskih veličina široj populaciji stručnjaka i entuzijasta. Istraživanje koje je ovde prezentovano odnosi se na analizu rada MEMS mikrofona kao jednog od pomenutih senzorskih uređaja, kada se on u sprezi sa Raspberry Pi mikroracunarom koristi za snimanje impulsnog odziva prostorije. Izvršeno je poređenje rezultata sa onim dobijenim mernom akustičkom opremom u istim uslovima rada.

#### AK1.5 UTICAJ COVID 19 ZAŠTITNIH MASKI NA RAZUMLJIVOST GOVORA U SRPSKOM JEZIKU

*Miloš Bjelić, Elektrotehnički fakultet, Univerzitet u Beogradu, Serbia*

*Tatjana Miljković, Elektrotehnički fakultet, Univerzitet u Beogradu, Serbia*

*Miomir Mijić, Elektrotehnički fakultet, Univerzitet u Beogradu, Serbia*

*Dragana Šumarac Pavlović, Elektrotehnički fakultet, Univerzitet u Beogradu, Serbia*

U ovom radu prikazana je analiza uticaja zaštitnih maski za lice na razumljivost govora. Analizirana su tri različita tipa zaštitnih maske koje se koriste u pandemijskim uslovima (pamučna maska, hirurška maska i maska N95). Takođe, analiziran je uticaj zaštitnog transparentnog vizira. Na osnovu govora nekoliko osoba utvrđen je oblik spektra dugovremenog govora u srpskom jeziku u slučaju upotrebe zaštitnih sredstava. Izvršeno je nekoliko subjektivnih testova u kojima je merena logatomska razumljivost govora sa i bez zaštitnih maski. Eksperimenti su organizovani u kontrolisanim uslovima (slušanje preko slušalica) i u prostoriji sa velikim vremenom reverberacije. Pokazano je da se prilikom korišćenja zaštitne maske N95 ostvaruje najbolja razumljivost govora u srpskom jeziku u odnosu na druga dva tipa analiziranih maski.

#### AK1.6 IZDVAJANJE REŽIMA PRAZNOG HODA MOTORA SA UNUTRAŠNjim SAGOREVANJEM NA OSNOVU AUDIO ZAPISA

*Marko Milivojčević, The School of Electrical and Computer Engineering of Applied Studies Belgrade, Serbia*

*Emilija Kisić, The School of Electrical and Computer Engineering of Applied Studies Belgrade, Serbia*

*Dejan Ćirić, Faculty of Electronic Engineering, University of Niš, Serbia*

U ovom radu je predstavljen postupak za prepoznavanje i izdvajanje režima praznog hoda motora sa unutrašnjim sagorevanjem putničkih vozila na osnovu audio zapisa prikupljenih na ulazu u podzemnu garažu. Analiza audio zapisa je realizovana u vremenskom domenu, kako bi se obrada signala svela na što minimalnije zahteve u pogledu potrebne procesorske snage akvizicionog sistema sa baterijskim napajanjem. Celokupan postupak prepoznavanja i izdvajanja audio zapisa koji odgovara režimu praznog hoda SUS motora putničkih vozila realizovan je upotrebom programskog jezika Python. Cilj predstavljenog postupka je priprema velikog broja prikupljenih audio signala za dalju analizu u pogledu karakterističnih audio obeležja i upotrebu u obuci neuralnih mreža.

# **Antennas and propagation/ Antene i prostiranje (AP)**

## **SESSION/SESIJA API1+AP1**

Wednesday/Sreda, September/Septembar, 08<sup>th</sup>, 16:15 – 17:00, Room 1/Soba 1

### **Chair/Predsedavajući:**

**Branko Kolundžija, University of Belgrade – School of Electrical Engineering, Serbia**

#### **API1.1 INFLUENCE OF VARIOUS EM MODELS OF AN AIRCRAFT TO MONOSTATIC RCS**

*Tomislav Milošević, WIPL-D, Serbia*

This paper outlines influence of four EM models of an electrically large aircraft on monostatic RCS results at 2.00 GHz. The differences in calculated RCS results suggest the importance of a choice of an EM model depending on the particular scope. The paper provides better understanding of some of EM scattering effects frequently addressed by engineering, scientific, and military working groups interested in RCS. Software tool used for simulations and model manipulations is a full wave 3D EM Method-of-Moments based software with Surface Integral Equations applied to quadrilateral mesh elements.

#### **API1.2 UTILIZATION OF CHARACTERISTIC MODE ANALYSIS IN COUPLED RESONATORS MICROSTRIP FILTER DESIGN**

*Ana Đurđević, University of Belgrade - School of Electrical Engineering, Serbia;*

*Milka Potrebić, University of Belgrade - School of Electrical Engineering, Serbia*

Examination of resonant frequency and coupling coefficient is essential part in microwave filters design with coupled resonators. We introduce Characteristic Mode Analysis (CMA) based method for calculation of coupling curve, applied to microstrip resonators. The main advantage of this approach is simplicity, due to CMs independency of any external sources. The results for coupling curve are presented and cross-checked with results obtained by equivalent two ports microstrip model with feeding lines. A very good agreement between the two methods is observed.

#### **API1.1 KARAKTERISTIKE MATERIJALA ZA ŠTAMPANE ANTENE U OPSEGU 65-110 GHZ**

*Nikola Bošković, Institut za Fiziku Beograd, Serbia*

*Miloš Radovanović, Institut za Fiziku Beograd, Serbia*

Izbor materijala igra presudnu ulogu u karakteristikama štampanih antena. Ovo je naročito kritično na W- opsegu, gde je mehanizam gubitaka značajno izmenjen, zbog čega veoma mali broj standardnih dielektrika može biti korišćen. Radi suzbijanja parazitnih modova i površinskih talasa, debljina dielektrika mora biti veoma mala u odnosu na učestanost, što dovodi do toga da efekat površinske hrapavosti bakarne provodne folije ima dominantan uticaj na gubitke. U ovom radu je prikazan značaj izbora odgovarajuće folije kao i njen uticaj. Zaključci su praćeni simulacijama i merenjima.

# Control Systems/ Automatika (AU)

## SESSION/SESIJA AUI1:

Wednesday/Sreda, September/Septembar, 08<sup>th</sup>, 15:00 – 17:00, Room 2/Soba 2

### Chair/Predsedavajući:

**Boban Veselić, Elektronski fakultet, Univerzitet u Nišu, Serbia**

#### AUI1.1 MULTIPURPOSE REMOTE MONITORING SYSTEM BASED ON MICROSERVICE ARCHITECTURE

*Luka Bjelica, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Miloš Panić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Marko Pejić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

This paper presents a cloud-native, multi-purpose, and reusable system for collecting, processing and storing data, with the aim of monitoring an arbitrary physical system. The proposed system can be divided into three main parts: a private network containing a set of microservices that perform complete data processing, applications that implement the low-level logic for collecting data from remote sensors, and a web client which enables interaction between the user and the rest of the system. The final product of this paper is a system based on the microservice architecture named isobar.ot, that allows monitoring of the chosen set of values of an arbitrary physical system, through a simple and functional user interface. Using the system presented in this paper, the user is able to control the entire course of remote monitoring: from the selection and specification of the collected data scheme, through the definition of alarm values, to displaying changes of values and alarms in real-time.

#### AUI1.2 INTEGRATED PARTICLE FILTER FOR MULTI TARGET TRACKING

*Zvonko Radosavljević, VTI, Serbia*

*Dejan Ivković, VTI, Serbia*

*Branko Kovačević, School of Electrical Engineering, University of Belgrade, Serbia*

Target tracking in heavy cluttered environment requires methodology for false track discrimination and data association. Recently, we present a new particle filter (PF) approach which recursively calculates the probability of target existence for the false track discrimination. Our approach treats possible detections of targets followed by other tracks as additional clutter measurements. It starts by approximating the a priori probabilities of measurement origin. The posterior data association probabilities are calculated to discriminate clutter measurements when updating trajectory probability density function. A new complete recursive track initiation, confirmation and deleting algorithm based on PF and Integrated Track Splitting (ITS) and named Integrated Particle Filter (IPF) is presented. Through the extended simulations showed the effectiveness of this approach in a five targets scenario.

#### AUI1.3 CONSENSUS ON THE AUXILIARY VARIABLES IN DISTRIBUTED GRADIENT- BASED TEMPORAL DIFFERENCE ALGORITHMS

*Milos Stankovic, Singidunum Univeristy, Vlatacom Institute, Serbia*

*Marko Beko, Instituto Superior Tecnico, Universidade de Lisboa, Portugal*

*Nemanja Ilic, Technical College of Applied Studies, Serbia*

*Srdjan Stankovic, Faculty of Electrical Engineering, University of Belgrade, Serbia*

In this paper we discuss important properties of two novel distributed algorithms for iterative multi-agent off-policy learning of linear value function approximation in Markov Decision Processes (MDP). The algorithms are derived using the off-policy Gradient Reinforcement Learning (GRL) methodology, together with linear dynamic consensus iterations over an underlying inter-agent communication network represented by directed graphs. The proposed algorithms are entirely decentralized, offering new possibilities for choosing different behavior policies while evaluating one single target policy. The presented algorithms formally differ only in the way of applying consensus iterations to the so-called



auxiliary variables. The presented proof of weak convergence of both algorithms represents a firm basis for deriving relevant conclusions concerning the role of the consensus iterations. It is shown that the algorithm utilizing consensus on the auxiliary variables shows slightly inferior asymptotic properties, but can provide a higher convergence rate. The figure of merit of each of the algorithms is presented and discussed using the theoretical results obtained under generally nonrestrictive assumptions.

#### AUI1.4 HOUGH TRANSFORM IN VISUAL PRODUCT QUALITY CONTROL

*Aleksandra Marjanovic, School of Electrical Engineering, University of Belgrade, Serbia*

*Sanja Vujnović, School of Electrical Engineering, University of Belgrade, Serbia*

*Zeljko Djurovic, School of Electrical Engineering, University of Belgrade, Serbia*

Product quality inspection is one of the indispensable steps in the production process, and there are more and more factories that are trying to automate that procedure by using computer vision algorithms. Additional efforts are made to keep these algorithms simple and fast when time is of the essence. This paper relies on Hough transform as a standard tool in image processing and discusses its possibilities in a time-constrained scenario. Being that the considered product is ball-shaped, the extension of Hough transform for circle detection is used to detect product in appropriate cells on the conveyor belt. The problem setup may seem easy, but unpredictable parameters of the industrial surroundings make it challenging. The detection algorithm is tested on a real-life image database collected at one chemical factory in Serbia.

#### AUI1.5 SOME NEW RESULTS ON STABILITY OF INCOMMENSURATE FRACTIONAL SYSTEMS AND THEIR LP-NORMS – INVITED PAPER

*Rachid Malti, Institut Universitaire de Technologie de Bordeaux, France*

Stability of fractional systems is yet an open problem especially when dealing with incommensurate differentiation orders. The objective of the invited talk is twofold. First of all, a new method for determining stability regions, in the parametric space, of fractional incommensurate systems are presented. It is based on interval arithmetics and allows, beyond the stability property, to specify the regions in the parametric space that have the same number of unstable poles. Hence, all transfer functions which parameters belong to the same stability region have the same stability property. Contrary to rational systems, the stability property of fractional systems does not guarantee the existence (or the boundedness) of the  $L_p$ -norms,  $1 \leq p \leq \infty$ , of its impulse response. Hence, the second objective of the talk is to examine the existence conditions of these  $L_p$ -norms. The established results are used to choose a performance index for evaluating stable feedback control system performances.

#### AUI1.6 APPLICATION OF CASCADE CONTROL IN THE PROCESS OF FLUE-GAS DESULFURIZATION OF THERMAL POWER PLANT

*Goran Kvascev, University of Belgrade, School of electrical engineering, Serbia*

*Zeljko Djurovic, University of Belgrade, School of electrical engineering, Serbia*

*Avram Avramovic, TE DRMNO - Kostolac, Serbia*

The paper presents the use of cascade control for the needs of an efficient flue-gas desulphurization process in the thermal power plant TE KO Drmno. A system for reducing the content of sulfur oxides ( $SO_2$ ) in flue exhaust gases - desulphurization has been implemented within two thermal power plants units. The technological process, control structure, implementation of cascade control and plant operation results are presented. By applying the proposed control structure, the efficient operation is achieved of the entire system in terms of the regulations of the European Commission in terms of emissions of sulfur oxides and particles, but also electricity consumption and energy efficiency. The goals that the plant was supposed to meet were achieved, as well as the economic justification of the entire project

## SESSION/SESIJA AU1:

Wednesday/Sreda, September/Septembar, 08<sup>th</sup>, 17:15 – 18:45, Room 2/Soba 2

### Chair/Predsedavajući:

**Milan Rapaić, University of Novi Sad, Faculty of Technical Sciences, Serbia**

#### AU1.1 UBLAŽAVANJE ČETERINGA DIGITALNOG REGULATORA PROMENLJIVE STRUKTURE ZA LINEARNE SISTEME

*Boban Veselić, Elektronski fakultet, Univerzitet u Nišu, Serbia*

*Čedomir Milosavljević, Elektrotehnički fakultet, Univerzitet u Istočnom Sarajevu, Serbia*

*Branislava Peruničić-Draženović, Elektrotehnički fakultet, Univerzitet u Sarajevu, Bosnia and Herzegovina*

*Senad Huseinbegović, Elektrotehnički fakultet, Univerzitet u Sarajevu, Bosnia and Herzegovina*

*Milutin Petronijević, Elektronski fakultet, Univerzitet u Nišu, Serbia*

U radu se ispituje mogućnost smanjenja četeringa u kliznom režimu jednog digitalnog regulatora promenljive strukture namenjenog za linearne sisteme sa ograničenim upravljačkim ulazom. Nelinearna diskontinualna funkcija relejnog tipa, koja je sastivni deo originalnog zakona upravljanja, zamenjena je adekvatnom kontinualnom aproksimacijom. Analizirana je stabilnost modifikovanog sistema i istaknute su uočene osobine sistema. Dobijeni teorijski zaključci su potvrđeni simulacionom proverom na numeričkom primeru.

#### AU1.2 AUTONOMNO KRETANJE BESPOSADNOG VOZILA PO ZADATOJ PUTANJI PRIMENOM ALGORITMA SA AKTIVNIM POTISKIVANJEM POREMEĆAJA

*Momir Stankovic, Vojna akademija, Univerzitet odbrane u Beogradu, Serbia*

*Stojadin Manojlovic, Vojna akademija, Univerzitet odbrane u Beogradu, Serbia*

U radu je predložen algoritam autonomnog kretanja besposadnog vozila po zadatoj putanji primenom koncepta upravljanja sa aktivnim potiskivanjem poremećaja. Nelinearnosti kinematike kretanja i poremećaji linearne i ugaone brzine vozila su formulisani u vidu totalnog poremećaja. Za estimaciju stanja nominalnog modela i totalnog poremećaja, kao dodatne promenljive stanja, projektovan je prošireni opservers stanja. Na bazi estimacija i dostupnih merenja formulisana je upravljački zakon za aktivno potiskivanje totalnog poremećaja u realnom vremenu i upravljanje kretanjem vozila sa definisanom dinamikom praćenja zadate putanje. Simulacionom analizom predloženog algoritma sa tipičnim modelom pogona guseničnog besposadnog vozila je pokazana efikasnost predloženog rešenja u različitim scenarijima praćenja zadate putanje.

#### AU1.3 СИСТЕМИ ЗА ПОДРШКУ ОДЛУЧИВАЊУ БАЗИРАНИ НА ВЕШТАЧКОЈ ИНТЕЛИГЕНЦИЈИ У ТРЕТМАНУ УМЕРЕНЕ ФОРМЕ БИЛИЈАРНОГ ПАНКРЕАТИТИСА

*Anja Buljević, Faculty of Technical Sciences, Novi Sad, Serbia*

*Aleksandar Gluhović, New Hospital, Novi Sad, Serbia*

*Mirna Kapetina, Faculty of Technical Sciences, Novi Sad, Serbia*

*Aleksandar Knežević, Clinical Center of Vojvodina, Novi Sad, Serbia*

*Zoran Jelić, Faculty of Technical Sciences, Novi Sad, Serbia*

У оквиру овог рада представљено је једно решење система за подршку одлучивању у лечењу умерене форме билијарног панкреатитиса. На основу параметара и показатеља из клиничке праксе, развијен је систем за усмеравање лекара приликом избора методе и поступка лечења овог запаљења панкреаса. Због релативно малог скупа података, услед специфичних медицинских процедура, избор релевантних обележја потврђен је кроз два формализма: корелационом анализом и стаблом одлучивања. На основу одабраних обележја, до финалног решења се долази уз ослонац на теорију потпорних вектора. Предложено решење нашло је своју примену у клиничкој пракси.

#### AU1.4      PREDIKCIJA ISHODA PROTETIČKE REHABILITACIJE NAKON AMPUTACIJE DONJIH EKSTREMITETA UZ OSLOMAC NA ALGORITME VEŠTAČKE INTELIGENCIJE

*Jovana Arsenović, Faculty of Technical Sciences Novi Sad, Serbia*

*Aleksandar Knežević, Faculty of Medicine University of Novi Sad, Serbia*

*Mirna Kapetina, Faculty of Technical Sciences Novi Sad, Serbia*

*Zoran Jeličić, Faculty of Technical Sciences Novi Sad, Serbia*

Protetička rehabilitacija trenutno predstavlja najbolji tretman za pacijente sa amputacijom donjih ekstremiteta. Međutim, fabrikacija proteze i prateća protetička rehabilitacija predstavljaju veoma dug i skup proces koji nekadane dovodi do poboljšanja mobilnosti i kvaliteta života pacijenata. Zbog toga je neophodno predvideti ishod rehabilitacionog tretmana. Glavni zadatak ovog rada bio je da se napravi alat, uz oslonac na algoritme veštačke inteligencije, koji bi se mogao primeniti u ranim fazama, kako bi se napravila što bolja predikcija ishoda rehabilitacije pacijenata sa amputacijom donjih ekstremiteta, odnosno kako bi se predvideo K-nivo (engl. Medicare Functional Classification Level, K-level), ishod testa dvominutnog hoda (engl. two minute walk test) i testa ustani i kreni (engl. timed up and go test). Evaluacija modela vršena je nad realnim podacima pacijenata Klinike za rehabilitaciju, Kliničkog centra Vojvodine. Dobijeni rezultati pokazuju značajno poboljšanje, u pogledu performansi klasifikatora, u odnosu na prethodne metode i potvrđuju izbor nekih od najznačajnijih parametara prilikom identifikacije pacijenata.

# Biomedical Engineering/ Biomedicinska tehnika (BT)

## SESSION/SESIJA BTI1

Friday/Petak, September/Sepembar, 10<sup>th</sup>, 09:00 – 11:30, Room 1/Soba 1

### Chair/Predsedavajući:

**Academician Prof. Dr Dejan B. Popović, Serbian Academy of Sciences and Arts  
Milica Janković, University of Belgrade, School of Electrical Engineering, Serbia**

### BTI1.1 EMG FEEDBACK FOR IMPROVED CONTROL OF MYOELECTRIC HAND PROSTHESES – INVITED PAPER

*Strahinja Dosen, Department of Health Science and Technology, Aalborg University, Denmark*

*Pranav Mamidanna, Department of Health Science and Technology, Aalborg University, Denmark*

*Jack Tchimoto, Department of Health Science and Technology, Aalborg University, Denmark*

*Filip Gasparic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Nikola Jorgovanovic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

Myoelectric prostheses can compensate for the motor functions that are lost due to an amputation. However, none of the commercial prostheses restores somatosensory feedback to their users. A conventional approach to providing the missing sensory information is to read the data from the sensors embedded in the prosthesis and transmit this information back to the subject by stimulating the skin of the residual limb mechanically or electrically. However, we have proposed a substantially different approach to closing the control loop. In this scheme, the tactile feedback does not convey the output of the prosthesis (sensor data) but its command input, namely, the magnitude of the myoelectric signals generated by the user (so-called EMG feedback). In this lecture, we will explain that this method facilitates the natural proprioceptive feedback from the muscles (sense of contraction) and thereby allows predictive control of prosthesis grasping force. We will also present results illustrating that EMG feedback outperforms conventional force feedback in terms of accuracy and robustness. Finally, we will outline the potential for further developments of this approach.

### BTI1.2 WIRELESS SENSING AND CONTROL OF ACTUATION FOR MACHINES AND HUMANS - INVITED PAPER

*Nenad Jovicic, School of Electrical Engineering, University of Belgrade, Serbia*

To a greater or lesser extent, wireless sensors and control systems have been used for decades in various areas of life and work. First implementations in the industry were intended for reliable transmission of simple remote control commands. Manipulating machines without complicated wiring has encouraged the creation of many ideas for applying wireless technologies in biomedical engineering. However, biomedical systems were often unpredictable, the operation in the environment in which they were applied was not always controllable, and as it turned out that simple technology transfer between industry and human applications was not trivial, sometime even inappropriate. Expansion of consumer market and development of computer networks and mobile telephony in the last decades led to the rapid growth of many wireless standards resulting in broadband, narrowband, personal, local, global, and other wireless technologies. The development of technology gives a new impetus to its applications in industry and afterward in life sciences and medicine. The talk is a retrospective of historical, past, present, and future challenges faced by wireless systems used in industry and biomedicine. Typical industrial and biomedical applications will be analyzed where different parameters like high bandwidth, low latency, or high energy efficiency are essential. Insights on how new wireless standards enable us to apply modern methods of big data processing, cloud computing, and artificial intelligence will be given. The special attention will be put on the bottlenecks in domains of security and reliability. Finally, the theoretical analysis will be supported by two examples of use of Wi-Fi wireless communication, on one industrial and one biomedical system.

### BT11.3 A MEASURE OF SPASTICITY BASED ON THE EXPONENTIAL FIT OF THE KNEE JOINT TORQUE ESTIMATED FROM THE GONIOGRAM DURING THE PENDULUM TEST

*Antonina Aleksic, Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Serbia  
Dejan B. Popović, Serbian Academy of Sciences and Arts, Serbia and Aalborg University, Aalborg, Denmark*

Pendulum test is a method to quantify the spasticity. We used the goniogram recorded during the pendulum test to estimate the knee joint torque based on the model which considers spastic reflex activity. We fitted the exponential curve  $T_h = ae^{-bt}$  to the estimated knee joint torque to calculate the parameters  $a$  and  $b$ . We compared the scaled value  $\log a/b$  with the modified Ashworth score. We used 8 sets of data collected in a clinical study with six complete paraplegic subjects. The comparison shows that the ratio  $a/b$  correlates with the MAS scores; thereby, can be used as a measure of spasticity. The advantage of using the ratio  $a/b$  is that this score is not rater dependent and that the scores are real numbers compared the MAS scores; thereby, providing better resolution of the level of spasticity.

### BT11.4 MULTIPLE MEASUREMENTS BY A PENDULUM TEST IMPROVE THE SPASTICITY ASSESSMENT IN SCI SUBJECTS

*Nikola Babić, University of Belgrade, Serbia  
Radoje Čobeljić, Clinic for Rehabilitation "Dr Miroslav Zotović", Serbia  
Slađana Kostić-Smith, Serbia  
Lana Popović Maneski, Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Serbia*

We present the variability of the spasticity scores during three consecutive days using the case series clinical study data with spinal cord injured (SCI) subjects. We assessed the spasticity by the Pendulum Test (PT) and Ashworth Scale (AS) scores. We measured the spasticity on the three consecutive days before and after the period of the treatment. Three subjects with SCI participated in the study. We found large variability from day to day. The PT score had more significant variability compared with the AS. The results suggest that the three consecutive testing by using the pendulum test and PT score on different days provide a better assessment of spasticity being essential in evaluating the treatment protocol

### BT11.5 PROOF OF CONCEPT PLATFORM OF AN ELECTROTACTILE BRAIN COMPUTER INTERFACE

*Marija Novicic, School of Electrical Engineering, University of Belgrade, Serbia  
Vera Miler-Jerković, Innovation Center, School of Electrical Engineering, University of Belgrade, Serbia  
Olivera Đorđević, Faculty of Medicine, University of Belgrade, Serbia  
Ljubica Konstantinović, Faculty of Medicine, University of Belgrade, Serbia  
Andrej Savić, School of Electrical Engineering, University of Belgrade, Serbia*

The aim of this paper is to present the concept and feasibility test of an electrotactile BCI platform consisted of EEG device, electrical stimulation device of nerves/muscles and custom software platform for device control. The developed application comprised GUI for device settings and synchronization of signal acquisition and stimulation control. Experiments for validation of the platform included transcutaneous electrical stimulation at 2 positions on the forearm for inducing somatosensory evoked potentials in the EEG signals in parallel with the tactile attention task performed by the subject. Initial results show that we were able to successfully acquire SEP with our system and that the tactile attention task modified SEP components in a physiologically congruent manner.

## **BT11.6 FREQUENCY BURST MODULATION OUTPERFORMS SPATIAL ENCODING IN MULTI-LEVEL VIBROTACTILE STIMULATION**

*Nikolina Maravić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Jelena Bulatović, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Filip Gašparić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Strahinja Došen, Department of Health Science and Technology, Aalborg University, Denmark*

*Nikola Jorgovanović, Faculty of Technical Sciences, University of Novi Sad, Serbia*

Haptic or tactile communication refers to communication through touch. Multichannel vibrotactile stimulation is a commonly used interface to provide tactile feedback. The feedback information is delivered to the subject by modulating stimulation parameters. The present manuscript investigates two approaches for encoding of the feedback information. To this aim, two experiments were performed in 20 healthy able-bodied subjects, whose task was to learn to distinguish eight levels of feedback variable using either burst frequency modulation or spatial locations of vibromotor activation. Vibrotactile feedback was delivered through vibration motors placed on the subject's forearm. The experiments consisted of three phases: a familiarization phase, a reinforced learning phase and a validation phase. The main outcome measure was the success rate in discriminating the levels of the feedback variable. The results have shown that burst frequency modulation (72% success rate) outperformed the spatial coding (64%). Therefore, the frequency encoding is the preferred approach in transmitting multilevel feedback information in vibrotactile feedback systems.

## **BT11.7 FEASIBILITY TEST OF ACTIVITY INDEX SUMMARY METRIC IN HUMAN HAND ACTIVITY RECOGNITION**

*Jelena Medarević, School of Electrical Engineering, University of Belgrade, Serbia*

*Marija Novičić, School of Electrical Engineering, University of Belgrade, Serbia*

*Marko Marković, Applied Rehabilitation Technology Lab, University Medical Center Göttingen, Germany*

The aim of this paper was to compare Activity Index summary metric for different activity groups and hand usages and test the feasibility of this parameter as a classification feature. Data acquisition was done with two smartwatches (one on each wrist) and a smartphone placed in the subject's pocket, using a custom software. Raw data from smartwatch accelerometers was used for further analysis. For labelled data segments, the Activity Index was calculated. Both statistical analysis that were done showed statistically significant differences between cases of hand usage (left, right, none, both) and between some of the activity groups (walking, sitting, standing, grasping, pouring, drinking, opening and closing cupboard, opening and closing bottle) respectively.

## **BT11.8 SPEECH VS. MUSIC CLASSIFICATION BASED ON EEG SPECTRAL FEATURES USING ARTIFICIAL NEURAL NETWORKS**

*Ivan Vajs, Innovation Center, University of Belgrade – School of Electrical Engineering, Serbia*

*Predrag Jekić, University of Belgrade – School of Electrical Engineering, Serbia*

*Aleksandra Marjanović, University of Belgrade – School of Electrical Engineering, Serbia*

*Milica Janković, University of Belgrade – School of Electrical Engineering, Serbia*

The response mechanisms to different neural stimuli are a challenging task in neuroscience research. The auditory activity (response to music, speech, noise, etc.) can cause various emotional and cognitive responses. The neural responses to speech and music are of particular significance since they are almost constantly present in day-to-day life. We present the classification of the reactions to speech and music based on the spectral EEG features. The mean values of four frequency intervals (corresponding to the theta, alpha, beta, and gamma rhythms) were assessed for seven brain regions. These features were then used as the inputs to the classification based on logistic regression and artificial neural networks; both were used to analyze each subject individually and all available data. Feature selection was also performed, and the classification algorithms were trained using all, a half, and a quarter of the features for comparing their importance and variance for each individual and the entire dataset. The best classification accuracy for a single subject was 85.8%, and an accuracy of 67.1% was achieved for all subjects. This result is promising and calls for the analysis of a larger dataset.

## BT11.9 HOW TV COMMERCIALS AFFECT ATTENTION AND MEMORY?

*Branan Kostić, University of Belgrade, School of Electrical Engineering, Serbia*

*Vanja Ković, University of Belgrade, Faculty of philosophy, Laboratory for Neurocognition and Applied Cognition, Serbia*

*Vera Miler Jerković, Innovation Center, School of Electrical Engineering in Belgrade, Serbia*

*Milica Janković, University of Belgrade, School of Electrical Engineering, Serbia*

Neuromarketing is an emerging multidisciplinary field that involves neuroscience methodology to estimate the reaction of consumers to marketing activities and the way they affect their decisions. The most used neurophysiological technique for neuromarketing studies is electroencephalography (EEG). We present a pilot EEG signals-based study on four participants. We investigated the effect of selected seven commercials on memorization and attention. Statistical analysis of extracted attention and memorization indices has shown high inter-subject variability. It has also demonstrated a statistically significant difference ( $p < 0.05$ ) between participant reactions on commercials on the individual level. Novel metric based on normalized total score of attention index, memorization index and self-assessment was proposed and demonstrated through the comparison of commercials.

## BT11.10 OPEN-SOURCE TOOL FOR 3D SEGMENTATION AND RENDERING OF ABDOMINAL CT SCANS

*Katarina Milićević, University of Belgrade – School of Electrical Engineering, Serbia*

*Otaš Durutović, University of Belgrade – School of Medicine and Clinical Centre of Serbia, Serbia*

*Milica Janković, University of Belgrade – School of Electrical Engineering, Serbia*

3D visualization of the size, shape, and location of the kidney stone as well as of the anatomical characteristics of the renal collecting system, surrounding tissue and blood vessels could significantly facilitate the surgeon's treatment planning for urolithiasis. Standard clinical Computed Tomography (CT) software does not offer the flexibility in the 3D display of individual or combined renal phases. In this paper we present a flexible and interactive open-source application for segmentation and 3D visualization of abdominal CT scans for the urolithiasis treatment planning. The usage of the new tool is demonstrated through the clinical examples and its advantages are explained in comparison with the output of the dedicated clinical software.

# Power Engineering/ Elektroenergetika (EE)

## SESSION/SESIJA EEI1

Friday/Petak, September/Sepembar, 10<sup>th</sup>, 15:00 – 17:00, Room 2/Soba 2

### Chair/Predsedavajući:

**Vladimir Katić, Univerzitet u Novom Sadu, Fakultet tehničkih nauka, Novi Sad, Serbia**

#### EEI1.1 SKIN EFFECT IMPLEMENTATION IN PARAMETERIZED WINDING FUNCTION MODEL OF AN INDUCTION MOTOR

*Aldin Kajević, University of Montenegro Faculty of Electrical Engineering, Montenegro*  
*Mario Mezzarobba, Department of Engineering and Architecture, University of Trieste, Italy*  
*Alberto Tessarolo, Department of Engineering and Architecture, University of Trieste, Italy*  
*Gojko Joksimovic, University of Montenegro, Faculty of Electrical Engineering, Montenegro*

The paper develops a method for skin effect implementation in recently derived parameterized winding function model of cage rotor induction motor. In that model number of rotor bars is free parameter. For any different number of rotor bars, rotor slot dimensions are different in order to preserve the total rotor copper volume but the slot shape is preserved. By defining the function of slot shape and using multilayer approach, rotor bar resistance and slot reactance can be calculated for any actual rotor speed and any number of rotor bars. The results from the model are given for two different number of rotor bars.

#### EEI1.2 OPERATION ANALYSIS AND DETERMINATION OF VIRTUAL SYNCHRONOUS MACHINE MODEL PARAMETERS

*Nikola Krstic, Faculty of Electronic Engineering, University of Niš, Serbia*  
*Milutin Petronijevic, Faculty of Electronic Engineering, University of Niš, Serbia*  
*Filip Filipovic, Faculty of Electronic Engineering, University of Niš, Serbia*

This paper presents the concept, model and simulation of virtual synchronous machine (VSM) operation and proposes a methodology for its parameter values selection. VSM was synchronized to the grid and its responses to given references of active and reactive powers were obtained, for different values of VSM parameters. Responses of grid-feeding and grid-supporting model of VSM, were considered. Special attention is paid to the formation of control loops for active and reactive power as basic structures in the VSM operation. Based on these control loops, values of VSM parameters are determined by pole adjustment method, which was the basic task of this paper. VSM model and the model of used power grid were made in Matlab/Simulink, in which results presented at the end of the paper, were generated.

#### EEI1.3 DESIGN OF LLC RESONANT TANK IN A LOW POWER DC/DC POWER CONVERTER

*Katarina Obradović, School of Electrical Engineering, University of Belgrade, Serbia*  
*Emilija Lukić, School of Electrical Engineering, University of Belgrade, Serbia*  
*Jovana Plavšić, School of Electrical Engineering, University of Belgrade, Serbia*  
*Aleksandar Milić, School of Electrical Engineering, University of Belgrade, Serbia*

Photovoltaic power conversion prosperity has put a spotlight on the resonant DC/DC converters. Namely, improved power density and lessened power losses can be achieved due to its soft switching feature. Step by step design procedure of the LLC resonant tank is proposed in this paper. Analysis of the parameters of the tank, capacitor selection and a detailed inductor design are demonstrated thoroughly. Finally, experimental results of the developed 1000W DC/DC converter with suggested LLC resonant configuration are presented.



## EEI1.4 IMPLEMENTATION AND TESTING OF BASIC ALGORITHMS IN PV SYSTEMS WITH BATTERIES ON A COMMON DC LINK

*Katarina Čeranić, School of Electrical Engineering, Belgrade, Serbia*

*Mila Gligorijević, School of Electrical Engineering, Belgrade, Serbia*

*Lazar Stojanović, School of Electrical Engineering, Belgrade, Serbia*

*Aleksandar Milić, School of Electrical Engineering, Belgrade, Serbia*

Photo-voltaic systems with batteries on a common DC link, ie. the concept of the Point of Common Coupling (PCC), are increasingly in use. In such systems, it is necessary to achieve the basic system functionalities, such as bidirectional battery operation, efficient Maximum Power Point Tracking (MPPT) regimes on the PV panels, as well as a constant voltage on a common DC link for the needs of consumers. In this paper, the basic algorithms for battery and panel operation in the MPPT mode are provided. The analysis was first verified in software packages and later by implementing algorithms on the developed low-power prototype of the system, where the basic functionalities were presented. Additionally, the robustness of the algorithms to power transients and disturbances which are common in the PCC systems was tested.

## SESSION/SESIJA EE1

Friday/Petak, September/Sepembar, 10<sup>th</sup>, 17:15 – 18:45, Room 2/Soba 2

### Chair/Predsedavajući:

**Marko Rosić, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Serbia**

## EE1.1 METOD ZA INŽENJERSKU PROCENU PROIZVODNJE VETROELEKTRANE

*Vladimir Katić, Univerzitet u Novom Sadu, Fakultet tehničkih nauka, Novi Sad, Serbia*

U ovom radu je razmatrana mogućnost brzog i jednostavnog procenjivanja proizvodnje električne energije planirane vetroelektrane na osnovu korišćenja raspoloživih podataka. Pošlo se od pretpostavke da su raspoložive usrednjene godišnje vrednosti brzine i gustine snage energije vetra. Razmatranjem različitih opcija za procenjivanje proizvodnje, predložena je jedna metoda. Radi verifikacije ona je primenjena za jednu lokaciju i četiri vrste vetrogeneratora. Metoda je verifikovana poređenjem sa izračunatom energijom na bazi stvarnih rezultata merenja brzine vetra. Postignuta je zadovoljavajuća tačnost pogodna za inženjerske procene, čime je metoda opravdala mogućnost primene.

## EE1.2 PRIMENA ELEKTRIČNIH VOZILA ZA SMANJENJE DEFICITA SNAGE U SISTEMU

*Uroš Ognjenović, University of Montenegro - Faculty of Electrical Engineering, Montenegro*

*Saša Mujović, University of Montenegro - Faculty of Electrical Engineering, Montenegro*

*Lazar Šćekić, University of Montenegro - Faculty of Electrical Engineering, Montenegro*

EVs (electric vehicles) are one of the leading trends in the world when it comes to sustainable growth and reducing impact on the environment. EV penetration in power systems means an increased load, but it allows for planned charging and discharging which benefit both the system and the owners of EVs. This paper proposes the use of planned charging and discharging of EVs based on game theory, with the aim to reduce the power deficit in a system.

## EE1.3 MODELOVANJE SISTEMA ZA REGULACIJU POBUDE SINHRONOG GENERATORA PRIMENOM NELINEARNOG ARX

*Mihailo Micev, University of Montenegro, Montenegro*

*Martin Čalasan, University of Montenegro, Montenegro*

*Milovan Radulović, University of Montenegro, Montenegro*

In this paper, the application of a nonlinear auto – regression model with external input (ARX) in order to model a loaded synchronous generator is presented. The input signal to the synchronous generator is represented as the field voltage, while the output signal is actually the terminal voltage of the generator. Therefore, to estimate the parameters of the adopted model, it is necessary to use the field voltage and the terminal voltage signals, which form the input – output data set. Additionally, the proposed

experiment is based on changing the reference voltage of the synchronous generator excitation control system. The described procedure is implemented in the MATLAB Simulink software package. The results obtained using the proposed model of the synchronous generator coincide with high accuracy with the results obtained in Simulink.

#### EE1.4 IDENTIFIKACIJA PARAMETARA MAŠINE JS SA NEZAVISNOM POBUDOM POSLE REMONTA

*Miroslav Bjekić, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Serbia*

*Vojislav Vujičić, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Serbia*

*Marko Rosić, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Serbia*

*Marko Sućurović, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Serbia*

U radu je opisan postupak identifikacije parametara mašine jednosmerne struje sa nezavisnom pobudom posle izvršenog remonta. Snimljene su karakteristike praznog hoda generatora i mehaničke karakteristike motora za različite vrednosti priključnog napona, pobudne struje i dodatne otpornosti u kolo indukta. Takođe su određeni i gubici usled obrtanja. Eksperimentalni rezultati potvrđeni su na dva načina koristeći merač momenta i elektromagnetnu kočnicu. Dobijeni koeficijenti elektromotorne sile (EMS) i momenta su upoređeni sa ranijim nazivnim vrednostima i dato je objašnjenje dobijenih razlika.

#### EE1.5 SIMULACIJA HISTEREZISNIH PETLJI INTERPOLACIJOM HARMONIJSKIH KOMPONENTI MAGNETSKOG POLJA

*Srdan Divac, Faculty of technical Sciences in Čačak, University of Kragujevac, Serbia*

*Branko Koprivica, Faculty of Technical Sciences in Cacak, University of Kragujevac, Serbia*

Cilj ovog rada je prikaz postupka simulacije histerezisnih petlji feromagnetskog uzorka koja je sprovedena simulacijom vremenskih oblika jačine magnetskog polja (u nastavku magnetskog polja) i magnetske indukcije. Podaci za magnetsko polje i indukciju su dobijeni merenjem, pri kontrolisanom obliku magnetske indukcije, za dva razmatrana oblika - sinusni i trougaoni. Na osnovu izmerenih podataka su određeni harmonici magnetskog polja za poznate amplitude magnetske indukcije. Nove vrednosti ovih harmonika se određuju interpolacijom prethodno izračunatih vrednosti, za amplitudu magnetske indukcije od interesa. Na osnovu ovih harmonika se vrši simulacija novog vremenskog oblika magnetskog polja. Nova histerezisna petlja se simulira korišćenjem ovog magnetskog polja i nove simulirane magnetske indukcije odgovarajućeg oblika. U radu je opisan navedeni postupak simulacije, dato je poređenje interpoliranih i izračunatih amplituda harmonika i vremenskih oblika magnetskog polja, kao i histerezisnih petlji. Takođe, u radu je data odgovarajuća analiza i diskusija rezultata.

#### EE1.6 ANALIZA UTICAJA MAGNETSKE INTERAKCIJE FAZA NA KARAKTERISTIKE 8/6 SRM-A

*Dragan Mihić, School of Electrical Engineering, University of Belgrade, Serbia*

*Mladen Terzić, School of Electrical Engineering, University of Belgrade, Serbia*

*Žarko Koprivica, School of Electrical Engineering, University of Belgrade, Serbia*

*Bogdan Brković, School of Electrical Engineering, University of Belgrade, Serbia*

U cilju unapređenja performansi, rad prekidačkog reluktantnog motora (Switched Reluctance Motor-SRM) zahteva jednovremeno pobuđivanje više faza motora. Budući da magnetski polaritet pobuđenih faza motora može biti isti ili različit, u ovom radu je izvršena detaljna analiza uticaja magnetskog polariteta na fluksne obuhvate faza 8/6 SRM-a. Ova analiza je izvršena na osnovu statičkih karakteristika koje su dobijene korišćenjem modela baziranog na metodi konačnih elemenata (Finite Element Method-FEM) u softverskom paketu Ansys Electronics. Pored toga, imajući u vidu da kod 8/6 SRM-a korišćenjem standardnog asimetričnog polumostnog invertora (API) nije moguće ostvariti magnetsku simetriju faza, rezultujući efekti veoma izražene interakcije faza su analizirani na primeru odgovarajućih tranzijentnih talasnih oblika faznih struja i momenta.

# Electric circuits and systems, and signal processing/ Električna kola, električni sistemi i obrada signala (EK)

## SESSION/SESIJA EK11+EK1

Wednesday/Sreda, September/Septembar, 08<sup>th</sup>, 15:00 – 15:30, Room 3/Soba 3

### **Chair/Predsedavajući:**

**Branimir Reljin, School of Electrical Engineering, University of Belgrade, Serbia**

#### **EK11.1 COVID-19 AND OTHER CT SCAN AUTHENTICATION USING WAVELET BASED WATERMARKING**

*Amra Gicić, School of Electrical Engineering, University of Belgrade, Serbia*

*Ana Gavrovska, School of Electrical Engineering, University of Belgrade, Serbia*

Nowadays, it is essential to ensure the integrity of the medical image, especially for adequate region of interest (ROI) before taking any diagnostic decision, where watermarking is often used. In this paper, Covid-19 and other CT (Computerized Tomography) scans are analyzed using wavelet based watermarking under JPEG (Joint Picture Experts Group) compression attack. The structured method consisted of robust and fragile watermark, having in mind ROI, is implemented. JPEG compression attack is chosen since it is often used while saving case studies. This is of particular importance in the case of widely available Covid-19 CT scans of different resolutions. The CT scan structured watermarking shows promising results under JPEG attack. The results seem promising in both detection of image manipulation through fragile watermark and integrating visual logos through more robust approach.

#### **EK1.1 KRISTALNI FILTRI ZA OPSEG FREKVENCIJA 150 – 170MHZ**

*Dragi Dujkovic, Univerzitet u Beogradu - Elektrotehnički fakultet, Serbia*

*Irina Reljin, Univerzitet u Beogradu - Elektrotehnički fakultet, Serbia*

*Lenkica Grubišić, Institut Mihajlo Pupin, Beograd, Serbia*

*Snežana Dedić-Nešić, Institut Mihajlo Pupin, Beograd, Serbia*

*Ana Gavrovska, Univerzitet u Beogradu - Elektrotehnički fakultet, Serbia*

Tehnologija izrade filtara zasnovanih na kristalima kvarca je i dalje zahtevan tehnološki postupak iako je imao svoj maksimum osamdesetih godina prošlog veka. Međutim, i danas se koriste ove komponente u savremenim telekomunikacijama, naročito digitalnim, i to tamo gde je veoma bitno imati kvalitetne uređaje za prijem, predaju i prenos signala. Uslovi rada filtara i uređaja u koji su ugrađeni, pored električnih zahtevaju i dobre klimomehaničke radne karakteristike koje su definisane zahtevima korisnika. U radu su opisani kristalni filtri propusnici opsega, namenjeni za rad u spoljnim uslovima pri visokim frekvencijama, i to u opsegu od 150 do 170 MHz.

# Electronics/ Elektronika (EL)

## SESSION/SESIJA ELI 1

Thursday/Četvrtak, September/Septembar, 09<sup>th</sup>, 15:00 – 17:00, Room 3/Soba 3

### Chair/Predsedavajući:

**Marko Dimitrijević, University of Nis Faculty of Electronic Engineering, Serbia**

**Lazar Saranovac University of Belgrade, School of Electrical Engineering, Serbia**

### ELI1.1 MONITORING SYSTEM FOR AC CURRENT UP TO 20A

*Milan Savic, College of Applied Technical Sciences Niš, Serbia*

*Dejan Stevanovic, University of Nis Faculty of Electronic Engineering, Serbia*

*Miona Andrejević Stošović, Faculty of Electronic Engineering, Serbia*

This paper presents a system for AC current monitoring in home appliances up to 20A. It is implemented on a custom made PCB. System also measures voltage, line frequency, power factor, active power and total imported active energy. Measurement results can be obtained by a remote computer or some other device via serial RS-485 interface. Consumer is enabled to have bigger control over real-time current consumption by installing several monitoring devices and connecting them into a network

### ELI1.2 MATLAB/SIMULINK 1D MODEL OF LONGITUDINAL WAVE PROPAGATION THROUGH PIEZOCERAMIC RINGS

*Igor Jovanović, Faculty of Electronic Engineering, University of Niš, Serbia*

*Dragan Mančić, Elektronski fakultet, Serbia*

One-dimensional (1D) model of piezoelectric elements enable fast prediction of performance, as well as a good insight into the behaviour of piezoelectric elements and the entire ultrasonic transducer during operation. In this paper, the Matlab/Simulink 1D model of piezoceramic rings that include only thickness oscillation modes is presented, while radial oscillations are neglected. The use of equivalent electromechanical circuits in the modelling of piezoelectric elements did not obtain a larger amount of information in relation to the number of information obtained by applying constitutive piezoelectric equations. In addition, the presented model that directly relies on the constitutive piezoelectric equations enables better visualization of wave propagation in the transducer structure. The input electrical impedances for piezoceramic rings are calculated using the realized model and then compared with experimental results to validate the model.

### ELI1.3 ARDUINO-BASED GAS AND SMOKE DETECTOR REALIZED USING MQ-2 SENSOR

*Petar Stančić, Faculty of electronic engineering, University of Niš, Serbia*

*Aleksandra Stojković, Faculty of electronic engineering, University of Niš, Serbia*

*Miljana Milić, Faculty of electronic engineering, University of Niš, Serbia*

System for detecting carbon monoxide, particles of smoke and combustible gases is described in this paper. Detector is based on application of Arduino platform with MQ-2 sensor as a source of input signal. The gas sensor functioning principles and detector configuration are explained in details. The described detector could be successfully used for various gas leakage detection, alone, or as a part of more complex system. The experimental results are given for burning paper smoke and three types of combustible gases. They confirm good performance of the system.

#### ELI1.4 A CHISEL GENERATOR OF JTAG TO MEMORY-MAPPED BUS MASTER BRIDGE FOR AGILE SLAVE PERIPHERALS CONFIGURATION, TESTING AND VALIDATION

*Vukan Damnjanović, NOVELIC, Serbia*

*Vladimir Milovanović, NOVELIC, Serbia*

This paper presents a design of a JTAG to memory-mapped bus master bridge generator implemented using Chisel hardware design language. This type of digital module can provide convenient and practical means of configuring a wide range of peripheral circuitry with a memory-mapped slave interface attached to a bus interconnection, as well as of their testing and debugging. The peripherals can be configured by driving the input signals of the JTAG interface with the values that represent the previously defined instruction codes, thus initiating write or read data transactions on the interconnect bus through the master interface to their memory-mapped registers. The master interface can be either AXI4 or TileLink, depending on the characteristics of the whole system which the depicted bridge is a part of. The proposed generator offers the ability of creating slightly different modules by using different parameter selections. The implemented design has been extensively tested using various software simulations with a number of different slave peripherals and mapped and tested onto a commercial FPGA platform. These actions experimentally confirmed the previously made assumption of the utility and convenience of the proposed generator.

#### ELI1.5 ALLPASS BASED DOUBLE NOTCH IIR FILTERS WITH CONSTANT PHASE

*Goran Stančić, Faculty of Electronic Engineering University of Nis, Serbia*

*Ivana Kostić, Faculty of Electronic Engineering University of Nis, Serbia*

*Stevica Cvetković, Faculty of Electronic Engineering University of Nis, Serbia*

Narrow stopband filters with two notch frequencies and piecewise constant phase are investigated in this paper. The notch filters are determined by allpass subfilter phase approximation. Obtained filters with simple and double poles are compared in conditions when fractional part of coefficients is represented with limited number of bits.

#### ELI1.6 FREE/OPEN SOURCE EDA TOOLS APPLICATION IN DIGITAL IC DESIGN CURRICULA

*Aleksandar Pajkanovic, Faculty of Electrical Engineering, University of Banja Luka, Bosnia and Herzegovina*

This paper represents a report on how free and open source software EDA tools may be used to organize a digital integrated circuits design course at the university level, without any financial investments in licenses. The course is built around several publicly available processor cores. These are of different complexity so first intrinsic properties are investigated. Then, using more complicated designs we examine how to increase performance through pipeline and cache associativity configurations. In this way we introduce RISC-V ISA and Chisel into the curricula. Finally, we provide a short overview of tools for automated design, from RTL all the way to silicon.

#### ELI1.7 TWO APPROACHES TO AUTOMATIC CONFIGURATION OF RS-485 NETWORK

*Nikola Cvetković, University of Belgrade, School of Electrical Engineering, Serbia*

*Pavle Milenković, University of Belgrade, School of Electrical Engineering, Serbia*

*Nenad Jovičić, University of Belgrade, School of Electrical Engineering, Serbia*

*Vladimir Rajović, University of Belgrade, School of Electrical Engineering, Serbia*

The purpose of this paper is to provide an overview of common approaches to automatic configuration of half-duplex RS-485 network, as well as to introduce two alternative methods of automatic slave address configuration in a network. Described mechanisms will be analyzed and compared in terms of hardware and software complexity, while taking into consideration system robustness and implementation feasibility.

# Metrology/ Metrologija (ML)

## SESSION/SESIJA ML1

Thursday/Četvrtak, September/Septembar, 09<sup>th</sup>, 09:00 – 11:30, Room 2/Soba 2

### **Chair/Predsedavajući:**

**Dragan Pejić, Faculty of Technical Sciences, University of Novi Sad, Serbia**

#### **ML1.1 OBEZBEĐENJE VALIDNOSTI REZULTATA ISPITIVANJA NIVOA SNAGE SMETNJI PONAVLJANJEM MERENJA**

*Aleksandar Kovačević, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Serbia*

*Nenad Munić, Tehnički opitni centar u Beogradu, Generalštab Vojske Srbije, Serbia*

*Veljko Nikolić, Tehnički opitni centar u Beogradu, Generalštab Vojske Srbije, Serbia*

*Ljubiša Tomić, Vojnotehnički institut u Beogradu, Ministarstvo odbrane Srbije, Serbia*

Akreditovana laboratorija mora da preispituje svoje rezultate ispitivanja radi obezbeđenja njihove validnosti. Jedan od načina je ponavljanje ispitivanja na poznatom uređaju. U radu je prikazano merenje nivoa snage smetnji na kuvalu za vodu. Pri tome, praćenje validnosti rezultata ispitivanja se obavlja u skladu sa utvrđenom procedurom.

#### **ML1.2 OČITAVANJE PSEUDOSLUČAJNOG KODA POMOĆU LINEARNOG NIZA FOTODETEKTORA KOD PSEUDOSLUČAJNIH POZICIONIH ENKODERA**

*Ivana Randelović, Elektronski fakultet u Nišu, Serbia*

*Dragan Denić, Elektronski fakultet u Nišu, Serbia*

*Goran Miljković, Elektronski fakultet u Nišu, Serbia*

U radu se predlaže primena linearnog niza fotodetektora za paralelno očitavanje pseudoslučajnog binarnog koda kod apsolutnih pseudoslučajnih pozicionih enkodera. Predloženom metodom očitavanja koda bi se eliminisala potreba za inicijalnim kretanjem osovine enkodera prilikom njegovog startovanja u slučaju serijskog očitavanja koda. Urađena je simulacija rada predloženog rešenja pozicionog enkodera primenom softverskog paketa LabVIEW. Digitalna simulacija je realizovana u formi dva programa, pri čemu jedan program simulira sistem za očitavanje koda pseudoslučajnog pozicionog enkodera, dok drugi program simulira funkcionisanje elektronskog bloka takvog enkodera. Predstavljena je analiza primene komercijalno dostupnog linearnog niza fotodetektora za očitavanje koda sa realizovanog staklenog diska enkodera na kome je pseudoslučajna kodna traka.

#### **ML1.3 SNIMANJE UI KARAKTERISTIKE ODVODNIKA PRENAPONA, INTERESANTNA ISKUSTVA**

*Dragan Pejić, Fakultet tehničkih nauka, Serbia*

*Boris Antić, Fakultet tehničkih nauka, Serbia*

*Zoran Mitrovic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Nemanja Gazivoda, Faculty of Technical Sciences, Serbia*

*Marina Subotin, Fakultet tehničkih nauka, Serbia*

Ovaj rad daje prikaz iskustava prilikom snimanja napoponsko-strujne (UI) karakteristike odvodnika prenapona (ZnO varistor). Snimanje je obavljeno korišćenjem dvokanalnog digitalnog osciloskopa. Napon sa krajeva varistora je dovođen na jedan kanala osciloskopa, a drugi kanal je iskorišćen za određivanje struje kroz varistor merenjem napona na redno vezanom šantu. Analiza je obavljena na dva načina: a) posmatranjem efektivne vrednosti napona i struje i b) posmatranjem trenutne vrednosti napona i struje varistora. Na kraju su dobijeni rezultati i primenjene metode upoređene sa oskudnim informacijama dostupnim u literaturi.

#### ML1.4 LOW COST REAL TIME TARGET TRACKING FOR IR HOMING HEADS

*Slobodan Pajić, EDePro doo, Serbia*

*Vladimir Kuzmanović, Faculty of Mathematics, University of Belgrade, Serbia*

The increase in performance of modern computers and the development of digital image sensors enabled many industries to rely on computer vision. Visual tracking is an important application of computer vision which requires extensive use of image processing algorithms. Visual tracking both in visible and IR spectrum can be the basis for terminal guidance of missiles. The video produced by the TV or IR camera can be used for tracking the target. Tracking the target in IR spectrum has many advantages in comparison with visual tracking, especially its resilience to fog, performance in low light conditions and night operations. Most notable drawback of using infrared imaging as a basis for tracking is low image contrast, low signal-to-noise ratio and low level of detail. In this paper we present a cost effective real time target tracking method for IR homing heads. The image processing, target detection and target position estimation procedures are introduced and explained in detail. The performance of the proposed method is analyzed and the results obtained are displayed. Finally, a conclusion is drawn and possible upgrades to the proposed method are considered.

#### ML1.5 SORTIRANJE PREDMETA PREMA BOJI AKVIZICIJOM VIDEA PRIMENOM VIRTUELNE INSTRUMENTACIJE

*Branko Stojković, Univerzitet u Kragujevcu, Fakultet tehničkih nauka u Čačku, Serbia*

*Branko Koprivica, Univerzitet u Kragujevcu, Fakultet tehničkih nauka u Čačku, Serbia*

*Alenka Milovanović, Univerzitet u Kragujevcu, Fakultet tehničkih nauka u Čačku, Serbia*

*Tatijana Dlačić, Univerzitet Crne Gore, Pomorski fakultet Kotor, Montenegro*

Cilj ovog rada je prikaz laboratorijske postavke za sortiranje predmeta prema boji, akvizicijom videa u programskom paketu LabVIEW. U radu su date osnovne informacije o programskim dodacima koji su potrebni za rad sa videom i slikom u programu LabVIEW i njihove mogućnosti primene, a ukratko je opisan i HSL sistem konverzije slike. Princip rada postavke za sortiranje predmeta prema boji, programska kalibracija USB kamere i postupak izvođenja laboratorijske vežbe su takođe opisani u radu. Na kraju rada su prikazani rezultati merenja mase sortiranih predmeta i data je odgovarajuća diskusija.

#### ML1.6 MOGUĆNOST PRIMENE HAMONOVIH PRESLOŽIVIH OTPORNIKA U NAIZMENIČNOM REŽIMU

*Stefan Mirković, Faculty of Technical Sciences, Serbia*

*Dragan Pejić, Fakultet tehničkih nauka, Serbia*

*Marina Subotin, Fakultet tehničkih nauka, Serbia*

*Nemanja Gazivoda, Faculty of Technical Sciences, Serbia*

*Zdravko Gotovac, Faculty of Technical Sciences, Serbia*

U većini primena u praksi Hamonovi (presloživi) otpornici nalaze svoje mesto u DC režimu. Njihova prvenstvena uloga nije da budu etaloni otpornosti, već etaloni prenosnog odnosa otpornosti. U ovom radu su izneti osnovni predlozi primene Hamonovih otpornika u AC režimu. Zbog svojih dobrih metroloških karakteristika u DC režimu, u radu su postavljene hipoteze koje pokušavaju da te karakteristike iskoriste u AC režimu.

#### ML1.7 METODA ETALONIRANJA MULTIFUNKCIJSKOG KALIBRATORA ZA ISPITIVANJE BEZBEDNOSTI ELEKTRIČNIH INSTALACIJA

*Dorđe Novaković, Faculty of Technical Sciences, Serbia*

*Nemanja Gazivoda, Faculty of Technical Sciences, Serbia*

*Dragan Pejić, Faculty of Technical Sciences, Serbia*

*Marjan Urekar, Faculty of Technical Sciences, Serbia*

*Ivan Gutai, Faculty of Technical Sciences, Serbia*

*Zdravko Gotovac, Faculty of Technical Sciences, Serbia*

U radu je opisan razvoj i validacija merne metode za etaloniranje vremena reakcije zaštitnih uređaja diferencijalne struje (RCD - Residual current device), kao jedne od funkcija multifunkcijskog kalibratora Time Electronics 5030. Metoda je razvijena sa ciljem kompletiranja sistema mernih metoda

kojima se realizuje etaloniranje svih funkcija multifunkcijskog kalibratora za ispitivanje bezbednosti električnih instalacija. U ovu svrhu je razvijen namenski firmver i hardver. Teorijski i eksperimentalno je pokazano da predložena metoda može uspešno da se primenjuje za etaloniranje vremena reakcije RCD uređaja. Merna nesigurnost realizovanog mernog sistema je dvadeset puta manja od merne nesigurnosti zadavanja vremena reakcije RCD uređaja u okviru multifunkcijskog kalibratora.

#### ML1.8 AUTOMATIZACIJA ETALONIRANJA DIGITALNIH MULTIMETARA

*Branislav Lukić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Dorđe Novaković, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Nemanja Gazivoda, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Platon Sovilj, Faculty of Technical Sciences, University of Novi Sad, Serbia*

U radu je opisan detaljan postupak realizacije jednog od rešenja automizacije procesa etaloniranja digitalnih multimetara pomoću kalibratora Times Electronis 5025. Za realizaciju aplikacije za etaloniranje digitalnih multimetara korišten je programski jezik Pajton sa Qt frejmvorkom.

#### SESSION/SESIJA ML2

Thursday/Četvrtak, September/Septembar, 09<sup>th</sup>, 15:00 – 17:00, Room 2/Soba 2

##### **Chair/Predsedavajući:**

**Platon Sovilj, Faculty of Technical Sciences, University of Novi Sad, Serbia**

#### ML2.1 MEASUREMENT OF ELECTRICAL POWER UNDER NONSINUSOIDAL CONDITIONS – **INVITED TALK**

*Branislav Djokić, National Research Council (NRC) of Canada, Canada*

Branislav Djokić (IEEE M'90-SM'97) received Dipl.Ing. degrees in Power Systems Engineering in 1981, in Electronics in 1984, M.Sc. and Ph.D. in Electrical Engineering in 1988 and 1993, respectively, from the University of Belgrade, Serbia. From 1982-1990, he was with R&D Institute Mihajlo Pupin, Belgrade. From 1990-1994 he was a Staff Member of the School of Electrical Engineering, Belgrade University. In 1994 he joined the Institute for National Measurement Standards, National Research Council of Canada. Dr. Djokić is a registered Professional Engineer in the Province of Ontario. He is IEEE PES Emerging Technologies Coordinating Committee Vice-Chair, IEEE Canada Other-Societies Committee Chair, IEEE Ottawa Section Educational Activities Chair and past Section Chair. In 2007, he received IEEE Regional Activities Board (RAB) Award for leadership in support of IEEE Ottawa Section. At NCSLI 2008, he received the best paper award in the international track for his paper on the calibration of Rogowski coils. His area of expertise is: new instrumentation and measurement methods for both highest-accuracy and industrial applications for AC electrical power, energy, high voltage, and high current, including calibration of Rogowski coils, which are widely used for measurements of large and transient AC currents in protective relaying, power and automotive industries, and plasma physics.

#### ML2.2 RAZVOJ MERNO-INFORMACIONOG SISTEMA ZA PODRŠKU PRI ETALONIRANJU TEMPERATURNIH SONDI

*Aleksandar Dimitrijevic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Djordje Novakovic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Nemanja Gazivoda, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Platon Sovilj, Faculty of Technical Sciences, University of Novi Sad, Serbia*

U ovom radu je opisan postupak automatizacije procesa etaloniranja temperaturnih sondi. Prikazan je način izrade aplikacije, implementacija određenih rešenja za sprečavanje grešaka, kao i algoritam po kojem se kod izvršava. Akcenat je stavljen na pojednostavljenju rada operatera. Uzete su u obzir konsultacije sa više korisnika čime se težilo optimalnom rešenju kako izgleda, tako i funkcionalnosti same aplikacije. Za realizaciju aplikacije korišćen je programski jezik Pajton sa QT frejmvorkom.



### ML2.3 UREĐAJ ZA ISPITIVANJE TAČKE ROSE

*Zdravko Gotovac, Faculty of Technical Sciences, University of Novi Sad, Serbia*  
*Rade Peranović, Faculty of Technical Sciences, University of Novi Sad, Serbia*  
*Dragan Pejić, Faculty of Technical Sciences, University of Novi Sad, Serbia*  
*Platon Sovilj, Faculty of Technical Sciences, University of Novi Sad, Serbia*

U ovom radu upoznaćemo se sa dizajniranjem i programiranjem jednog kompaktnog akvizicionog sistema koji se koristi u svrhe nadgledanja tačke rose. Upotrebom dostupnih i cenovno pristupačnih tehnologija moguće je napraviti akvizicioni sistem koji je značajno jeftiniji od trenutno ponuđenih na tržištu.

### ML2.4 IMPLEMENTACIJA KOMUNIKACIONIH I KONTROLNIH METODA U KONCEPTU INDUSTRIJE 4.0

*Zdravko Gotovac, Faculty of Technical Sciences, University of Novi Sad, Serbia*  
*Marjan Urekar, Faculty of Technical Sciences, University of Novi Sad, Serbia*

U ovom radu upoznaćemo se sa dizajniranjem i implementacijom komunikacionih i kontrolnih metoda korišćenjem široko rasprostranjenih tehnologija. Čitava ideja predstavlja logičan iskorak u uključivanje Industrije 4.0 u proizvodni process, kao i indirektno unapređivanje uređaja i radnog okruženja koji su realni dio proizvodnog procesa.

### ML2.5 SISTEM ZA MERENJE I REGULACIJU TEMPERATURE U ZAMRZIVAČIMA ZA ČUVANJE PFIZER-BIONTECH COVID-19 VAKCINE

*Milan Šaš, Fakultet Tehničkih Nauka, Serbia*  
*Bojan Vujičić, Fakultet Tehničkih Nauka, Serbia*  
*Dragan Pejić, Fakultet Tehničkih Nauka, Serbia*

U ovom radu biće prikazano rešenje za merenje i regulaciju temperature u zamrzivačima za čuvanje Pfizer-BioNTech COVID-19 vakcine na -70°C. Rad je baziran na Arduino Nano platformi koja se koristi za obradu podataka koje dobija iz kola koje meri napon na PT1000 senzoru temperature. Dalje, te podatke obrađuje i prikazuje na četvorocifrenom sedmosegmentnom displeju. Cilj rada jeste da se pokaže mogućnost projektovanja i implementiranja sistema za merenje i regulaciju temperature koja nije u standardnom opsegu merenja. Opseg temperature koji se ovim sistemom meri je od -100°C do 0°C.

### ML2.6 EDUKATIVNI PRISTUP ENKRIPTOVANOM PRENOSU PODATAKA U EMBEDDED I FRONTEND RAZVOJNIM OKRUŽENJIMA

*Ivan Gutai, Faculty of Technical Sciences, Novi Sad, Serbia*  
*Platon Sovilj, University of Novi Sad, Serbia*  
*Marina Subotin, Fakultet tehničkih nauka, Serbia*  
*Marjan Urekar, Fakultet tehničkih nauka, Serbia*  
*Jelena Milojević, University of Novi Sad, Serbia*  
*Milica Mitrović, University of Novi Sad, Serbia*

Pre IIoT-a (The Industrial Internet of Things), embedded programiranje i frontend programiranje nisu mogli da se nađu ni u istoj rečenici. Hardver koji je omogućio neprimetnu integraciju ove dve kompleksne oblasti je Espressif-ov ESP32 MCU (MicroController Unit). Tek kada je broj uređaja povezanih na internet dostigao značajnu cifru, u fokus je došla bezbednost podataka. ESP-NOW je Espressif-ova tehnologija za bežični prenos podataka. Prenos može biti enkriptovan i obezbeđuje bezbednu komunikaciju između više ESP32. HTTPS (Hypertext Transfer Protocol Secure) je protokol koji povećava bezbednost na internetu. Ovaj rad predstavlja uputstvo za konfigurisanje razvojnog okruženja za ESP32, ESP-NOW primer, primer HTTPS servera i prikaz programerske prakse za upravljanje greškama. Kao dodatak prikazan je i prilagodljivi grafički korisnički interfejs IIoT uređaja. U ovom trenutku postoji mnogo pitanja u embedded i frontend programiranju. U ovom radu je izabrana pitanja: ESP32 za hardver i C++ za firmver. JavaScript, HTML5 i CSS3 su neizbežan deo modernih industrijskih uređaja, pa je dat primer korišćenja JavaScript Highcharts biblioteke. Korišćena kombinacija hardvera i softvera košta manje od 10\$, što čini konfiguraciju pogodnom za zemlje u

razvoju. Highcharts biblioteka je vlasnički softver, ali u edukativne svrhe se može koristiti u okviru Creative Commons (CC) Attribution-Non-Commercial licence.

## ML2.7 EDUKATIVNI PRIMER GENERISANJA I OBRADE PODATAKA UZ ALATE DOSTUPNE U .NET 5, U DOMENU METROLOGIJE

*Ivan Gutai, Faculty of Technical Sciences, Novi Sad, Serbia*

*Platon Sovilj, University of Novi Sad, Serbia*

*Marina Subotin, Fakultet tehničkih nauka, Serbia*

*Dorđe Novaković, Fakultet tehničkih nauka, Serbia*

*Nemanja Gazivoda, Faculty of Technical Sciences, Serbia*

*Bojan Vujicic, FTN, Serbia*

Baze podataka predstavljaju oslonac kompletne aplikacije, a kreiranje arhitekture i izbor adekvatnih tehnologija iz godine u godinu postaje kompleksnije. Ovaj rad je kreiran kao praktično uputstvo i oslanja se na najnoviju iteraciju popularnog programskog jezika C# 9 i na relacionu bazu podataka, Microsoft-ov SQL Server, skraćeno MSSQL. Entity Framework Core je tehnologija koja značajno olakšava kreiranje i rad sa bazom podataka. Primenjen je eng. code first pristup i iz C# koda je kreirana baza podataka sa dve povezane tabele i inicijalno je popunjena tabela koja predstavlja šifarnik. Nakon kreiranja tabela, iz SQL Server Management Studio (SSMS) su kreirane dve skripte koje omogućavaju kreiranje tabela, bez upotrebe C# koda, tj. napisane su kao Structured Query Language (SQL) skripte. Kreirana je C# aplikacija koja generiše milion zapisa, koji zauzimaju 100 MB u relacionoj bazi i 152 MB kada se serijalizuju u JSON fajl uz pomoć Json.NET-a. Dat je primer korišćenja Xunit alata za testiranje. Dati su primeri proširivanja LINQ (Language-Integrated Query) funkcija Median i Mean. Prikazana su dva načina za očitavanje vrednosti iz baze, uz pomoć LINQ-a i uz pomoć SQL-a.

# Microelectronics and optoelectronics, nanosciences and nanotechnologies/ Mikroelektronika i optoelektronika (MO)

## SESSION/SESIJA MOI1

Wednesday/Sreda, September/Septembar, 08<sup>th</sup>, 15:30 – 17:00, Room 3/Soba 3

### Chair/Predsedavajući:

**Zoran Prijić, Faculty of Electronic Engineering, University of Niš, Serbia**

#### MOI1.1 SYNTHESIS AND CHARACTERIZATION OF THIN COPPER COATINGS OBTAINED BY SONOELECTRODEPOSITION METHOD

*Ivana Mladenović, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia*

*Jelena Lamovec, University of Criminal Investigation and Police Studies, Belgrade, Serbia*

*Stevan Andrić, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia*

*Miloš Vorkapić, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia*

*Marko Obradov, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia*

*Dana Vasiljević-Radović, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia*

*Vesna Radojević, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*

*Nebojša Nikolić, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia*

Influence of an intensity of ultrasonic mixing of electrolyte in a temperature range of 27-37°C and ultrasonic power intensity in the range of 3.77-18.84 W/cm<sup>2</sup> (10-50%) on a synthesis of fine-grained copper deposits was examined. Copper coatings were electrodeposited on a brass substrate in direct current (DC) regime with an applied current density of 50 mA•cm<sup>-2</sup>. The laboratory-made copper sulfate electrolyte was used without or with addition of additives. The variation of temperature under sonoelectrodeposition process and variation mixing intensity of electrolyte were ensured by using an ultrasonic probe. The produced Cu coatings were examined by optical microscope (OM) in order to observe the microstructural modification with variation ultrasonic parameters and for measuring imprints of Vickers indenter. The micro hardness properties of composite systems were characterized using Vickers micro indentation test. The composite hardness models Chicot-Lesage and Chen-Gao were used for the determination the coatings hardness and adhesion evaluation. Application of Atomic Force Microscopy (AFM) technique also confirmed the strong influence of ultrasonic mixing conditions of electrolyte onto change of the microstructure of copper deposits and surface roughness of the coatings. The maximum hardness, good adhesion properties and minimum micro surface roughness was obtained for the fine-grained Cu coating produced with amplitude of 50% ultrasonic mixing of electrolyte without additives and 30 % for electrolyte with additives.

#### MOI1.2 MAGNETIC FIELD GENERATOR FOR SIMULATION OF A VEHICLE MOVEMENT FOR A WIDE RANGE OF VELOCITIES

*Milan Stojanović, Faculty of Electronic Engineering, University of Niš, Serbia*

*Jana Vračar, Faculty of Electronic Engineering, University of Niš, Serbia*

*Ilija Neden Dimitriu, Roads of Serbia, Serbia*

*Ljubomir Vračar, Faculty of Electronic Engineering, University of Niš, Serbia*

This paper describes the LTSpice model of a magnetic field generator needed for testing a vehicle detector. This simulator reproduces magnetic field distortion equal to a vehicle when passing over the detector located in the road in real conditions. The electric circuit of the simulator described in this paper is a solenoid, PWM generator, and filter capacitors. The different values of capacitors are given for different vehicle velocities. The switching matrix is used for selecting the appropriate capacitor values to achieve simulation of different vehicle velocities.

### MOI1.3 ACTIVE MATRIX LIQUID CRYSTAL DISPLAY – AMLCD SWITCHING TIME MEASUREMENTS

*Branko Livada, Vlatacom Institute, Serbia*

Liquid crystal displays (LCD) are currently dominant in applications for visual content presentation. In the case of video content presentation, LCD switching time determines image appearance and perception. The photometric and temporal properties of LCDs are unfamiliar to many practitioners, especially switching time temperature dependence. In specific applications as ruggedized military displays temperature dependence is critical parameter for operation on low temperatures. Current liquid crystal display technology does not provide proper operation at low temperatures so additional heater should be incorporated into display design. The temperature dependence of switching time provides initial data determining heater design parameters. The short review of the LCD switching time theory is presented. The AMLCD switching time over temperature, method is described. The selected measurement results are presented and discussed.

### MOI1.4 HYPER FOCAL DISTANCE APPLICATION FOR LONG RANGE SURVEILLANCE CAMERA ZOOM LENS FOCUSING SETTINGS

*Saša Vujić, Vlatacom Institute, Serbia*

*Dragana Perić, Vlatacom Institute, Serbia*

*Branko Livada, Vlatacom Institute, Serbia*

Modern multi sensor surveillance systems integrate several multispectral imaging channels, laser range finder positioning (GNSS receiver) and heading (digital magnetic compass – north finding sensor) sensors. Imaging channels use motorized zoom lenses providing convenient and fast field of view (FOV) change. The fast FOV change to desired value, keeping the optimal image sharpness, is provided through selected FOV pre-set settings using zoom lens position setting to desired values. In addition to FOV settings it is useful to pre-set lens focus motor position. The zoom lens hyper-focal distance determination for selected FOV and lens focusing motor position setting accordingly is used as pre-set lens parameter definition. The short review of the motorized zoom lens design and their basic properties is presented. The lens depth of field and hyper focal distance are discussed and basic formulas are derived. The zoom lens based imaging channel calibration procedures selection depend on application. We presented in detail hyper-focal distance based focusing motor parameter setting as one of the calibration procedures used in our multi sensor imaging systems.

### MOI1.5 TEMPERATURE INFLUENCE ON THE PERFORMANCE OF P3HT:ICBA POLYMER SOLAR CELLS

*Ali R. Khalf, School of Electrical Engineering, University of Belgrade, Serbia*

*Jovana P. Gojanović, School of Electrical Engineering, University of Belgrade, Serbia*

*Nataša A. Ćirović, School of Electrical Engineering, University of Belgrade, Serbia*

*Petar S. Matavulj, School of Electrical Engineering, University of Belgrade, Serbia*

*Grand Ledet, Institute for Micromanufacturing, Louisiana Tech University, United States*

*Mark Hidalgo, Institute for Micromanufacturing, Louisiana Tech University, United States*

*Sandra Živanović, Institute for Micromanufacturing, Louisiana Tech University, United States*

Temperature (T) dependent performance of polymer solar cells (PSCs) with a poly (3-hexylthiophene) : indene-C60 bisadduct (P3HT:ICBA) active layer were investigated. The current-voltage (I-V) characteristics of devices with two different active layer thicknesses (ALTs) were measured within a temperature range of 20 °C-65 °C. The recorded I-V curves showed the S-shape deviation. The I-V curves were also simulated by a standard drift-diffusion model that includes the influence of the surface recombination on both electrode contacts. The Arrhenius-type temperature-dependent hole mobility was introduced in order to reproduce the experimentally observed temperature-dependent PSC behavior. The measured power conversion efficiency (PCE) and short-circuit current (Isc) changed nonmonotonically with T whereby detailed temperature trends differed for solar cells of different ALTs. The noticed effects were not present in theoretically predicted PCE and Isc. To match the simulated and experimental I-V characteristics the PCS internal quantum efficiency (IQE) was varied with T. We suggest that the obtained nonmonotonic IQE(T) dependence originates from changes in morphology caused by the influence of temperature and strongly correlates to the P3HT:ICBA thin-film thickness.

## SESSION/SESIJA MO1

Wednesday/Sreda, September/Septembar, 08<sup>th</sup>, 17:15 – 18:45, Room 3/Soba 3

### Chair/Predsedavajući:

**Branko Livada, Vlatacom Institute, Serbia**

#### MO1.1 EFEKTI ZRAČENJA I ODŽARIVANJA KOD NAPONSKO TEMPERATURNOM NAPREZANIH P-KANALNIH VDMOS TRANZISTORA SNAGE

*Sandra Veljković, University of Niš Faculty of Electronic Engineering, Serbia*

*Nikola Mitrović, University of Niš Faculty of Electronic Engineering, Serbia*

*Snežana Đorić-Veljković, University of Niš Faculty of Civil Engineering and Architecture, Serbia*

*Vojkan Davidović, University of Niš Faculty of Electronic Engineering, Serbia*

*Snežana Golubović, University of Niš Faculty of Electronic Engineering, Serbia*

*Danijel Danković, University of Niš Faculty of Electronic Engineering, Serbia*

U radu su prikazani efekti zračenja i odžarivanja kod p-kanalnih VDMOS (vertical double-diffused metal-oxide semiconductor) tranzistora snage koji su prethodno bili izloženi naponsko temperaturnom naprezanju tokom različitih unapred tačno utvrđenih vremenskih perioda. Ovaj eksperiment je sproveden kako bi se ispitali efekti naprezanja zračenjem kod komponenata koje su prethodno bile izložene drugim uticajima, odnosno naprezanjima. Primećeno je da je promena napona praga tokom ozračivanja malo više izražena kod komponenata koje su bile izložene naponsko temperaturnom naprezanju negativnom polarizacijom gejta nedelju dana, što može biti od značaja u slučaju kada su komponente primile visoke ukupne doze. Pored toga, primećeno je da kod komponenata koje su naponski temperaturno naprezane jedan sat, a zatim ozračene do 90 Gy pri pozitivnoj polarizaciji gejta, termički aktivirani procesi tokom odžarivanja nisu dovoljni da se napon praga smanji na vrednost pre naponsko temperaturnih naprezanja, što bi moglo biti od interesa u slučaju kada komponente rade u pooštrenim uslovima.

#### MO1.2 PORAST ELEKTROPROVODNOSTI KOD LI-JONSKIH BATERIJA UPOTREBOM MO NANO-PREVLAKA ELEKTROD

*Jovan Šetrajčić, Akademija nauka i umjetnosti Republike Srpske, Serbia*

*Siniša Vučenović, Univerzitet u Banjoj Luci, Prirodno-matematički fakultet, Bosnia and Herzegovina*

*Igor Šetrajčić, Akademija nauka i umjetnosti Republike Srpske, Serbia*

*Stevo Jaćimovski, Kriminalističko-policijski univerzitet, Serbia*

*Ana Šetrajčić-Tomić, Akademija nauka i umjetnosti Republike Srpske, Serbia*

*Dušan Ilić, Univerzitet u Novom Sadu, Fakultet tehničkih nauka, Serbia*

*Nikola Vojnović, Univerzitet u Novom Sadu, Fakultet tehničkih nauka, Serbia*

U radu su predstavljeni rezultati teoriskih istraživanja ponašanja fononskog podsistema u ultratankim metal-oksidnim (MO) prevlakama kakve se nanose na elektrode u Li-jonskim baterijama radi povećanja efikasnosti jonskog transporta. Primenjen je metod Grinovih funkcija i numeričkom analizom je pokazano da kod ultratankih filmova i to okomito na granične površi tog filma, dolazi do pojave izrazito pojačanog mehaničkog oscilovanja kristalne rešetke i formiranja stojećih talasa, čime fononi podstiču oslobađanje zarobljenih jona u graničnim slojevima elektroda i time povećavaju efikasnost jonskog transporta između elektroda, a time i doprinose uvećanju elektro-provođenja ovih baterija.

### MO1.3 PERFORMANSE SKLOPOVA TERMoelekTRIČNI MODUL-HLADNJAK NAMENJENIH SAMONAPAJAJUĆIM SISTEMIMA U USLOVIMA PRIRODNOG HLAĐENJA

*Aleksandra Stojković, Elektronski fakultet u Nisu, Serbia*

*Miloš Marjanović, Elektronski fakultet u Nišu, Serbia*

*Jana Vračar, Elektronski fakultet u Nišu, Serbia*

*Aneta Prijić, Elektronski fakultet u Nišu, Serbia*

*Zoran Prijić, Elektronski fakultet u Nišu, Serbia*

Sklopovi termoelektrični modul-hladnjak nalaze široku primenu u sistemima za konverziju termičke u toplotnu energiju i obrnuto. U ovom radu je analiziran izabrani termoelektrični modul u ulozi termoelektričnog generatora u sprezi sa šest različitih hladnjaka bliskih dimenzija pod uslovima prirodnog hlađenja. Razmatrana je efikasnost sklopova sa aspekta električnog napona predatog potrošaču pri različitim temperaturnim pobudama. Izvršena su eksperimentalna merenja i odgovarajuće numeričke simulacije, pri čemu su analizirani doprinosi pojedinih termoelektričnih efekata i mehanizama odvođenja toplote sa površina hladnjaka. Pokazano je da ravni hladnjaci od mikroporoznih materijala mogu adekvatno da zamene ekstrudirane aluminijumske hladnjake kod samonapajajućih sistema u uslovima prirodnog hlađenja.

### MO1.4 ANALIZA UPOREDNOG PRAĆENJA TEMPERATURE POVRŠINE OHLAĐENIH MATERIJALA PRI NJHOVOM ZAGREVANJU DO AMBIJENTALNE TEMPERATURE

*Denadić Stevan, Univerzitet u Beogradu, Rudarsko-geološki fakultet, Serbia*

*Tomić Ljubiša, Vojnotehnički institut, Serbia*

*Vesna Damjanović, Univerzitet u Beogradu, Rudarsko-geološki fakultet, Serbia*

*Katarina Nestorović, Vojnotehnički institut, Serbia*

U datom eksperimentalnom radu su termografskim metodama, pod istim uslovima, snimljeni a zatim i analizirani termogrami materijala potpuno različitih termofizičkih karakteristika. Navedeni materijali su izabrani jer imaju različita termoizolaciona svojstva i različito stanje površine.

# Microwave technique, technologies and systems/ Mikrotalasna tehnika, tehnologije i sistemi (MT)

## SESSION/SESIJA MTI1

Wednesday/Sreda, September/Septembar, 08<sup>th</sup>, 15:00 – 16:15, Room 1/Soba 1

### Chair/Predsedavajući:

**Nebojsa Doncov, Faculty of Electronic Engineering, University of Niš, Serbia**

#### MTI1.1 MODELING A PLANAR CIRCULAR LOOP ANTENNA USING ARTIFICIAL NEURAL NETWORKS

*Ksenija Pešić, Elektronski fakultet, Serbia*

*Zoran Stanković, Elektronski fakultet, Serbia*

*Nebojša Dončov, Elektronski fakultet, Serbia*

In this paper we present a neural model for planar circular loop antenna based on multilayer perceptron (MLP) network. This model is realized by means of two coupled MLP networks which separately provide the resonant frequency and the minimum value of  $S_{11}$  parameter for specified antenna dimensions. The model is trained within the certain range of input parameters (radius of the antenna and the ratio of the radius and the thickness of loop antenna) that allows for design of planar circular loop antennas operating in the frequency band (500 - 2800) MHz.

#### MTI1.2 MODELLING OF CONFORMAL ANTENNAS USING TIME-DOMAIN TLM METHOD

*Tijana Dimitrijević, Faculty of Electronic Engineering, University of Niš, Serbia*

*Ekrem Altinozen, The George Green Institute for Electromagnetics research, University of Nottingham, United Kingdom*

*Aleksandar Atanaskovic, Faculty of Electronic Engineering, University of Niš, Serbia*

*Jugoslav Jokovic, Faculty of Electronic Engineering, University of Niš, Serbia*

*Ana Vukovic, The George Green Institute for Electromagnetics research, University of Nottingham, United Kingdom*

*Phillip Sewell, The George Green Institute for Electromagnetics research, University of Nottingham, United Kingdom*

*Nebojsa Doncov, Faculty of Electronic Engineering, University of Niš, Serbia*

As textile antennas are seeing a major growth in recent years, there is a demand for understanding how they behave when exposed to a realistic environment such as different types of deformations. To achieve that, an appropriate, accurate and reliable modeling approach is requested. This paper provides results how the resonant frequency of a rectangular patch antenna is changed under bending, which can be used as a guidance when designing textile antenna. Results are derived by applying three different approaches based on different TLM meshes.

#### MTI1.3 REDUCED DIMENSIONS PLANAR RAT RACE COUPLER DESIGN

*Denis Letavin, UrFU, Russia*

*Dusan Nestic, University of Belgrade, Serbia*

The design of a rat race directional coupler was investigated in the Cadence AWR Design Environment program. By using low-pass filters instead of quarter-wave sections, it was possible to reduce the size of the device by 82.3%. In this case, the following deterioration of frequency characteristics occurred: narrowing of the operating frequency band by 6.2%, an increase in imbalance, and a decrease in matching. Also, the area of the compact double ring coupler was reduced by 84.4% while the bandwidth was narrowed by 13.6%.

#### MTI1.4 EXPERIMENTAL ANALYSIS OF ELECTROMAGNETIC INTERFERENCES ABSORBER INFLUENCE ON METAL ENCLOSURE IMMUNITY

*Nataša Nešić, Academy of Applied Technical and Preschool Studies Niš, Serbia*

*Slavko Rupčić, Faculty of Electrical Engineering, Computer Science and Information Technology Osijek, Croatia*

*Vanja Mandrić-Radivojević, Faculty of Electrical Engineering, Computer Science and Information Technology Osijek, Croatia*

*Nebojša Dončov, Faculty of Electronic Engineering Niš, Serbia*

This paper considers the experimentally conducted analysis of shielding effectiveness of an enclosure with electromagnetic interferences absorber placed at different positions inside. Dimensions of an absorber sheet are fitted to affect the enclosure's first resonant frequency in order to improve its protective function. An absorber sheet inside measured enclosure has an impact on the shielding effectiveness values not only at the first resonance but also in a wider frequency range.

#### MTI1.5 INCORPORATING A LOWPASS FILTER INTO A VERY WIDE BANDPASS FILTER TO SUPPRESS HARMONICS

*Dušan Nešić, University of Belgrade, Centre of Microelectronic Technologies, A Division of the ICTM, Serbia*

This paper presents an algorithm for suppression of higher harmonicas in response of the very wide bandpass filter (WBPF). Lowpass filter (LPF) is incorporated into the very wide bandpass filter to suppress harmonics. The LPF is consists of only three identical cells with uniform open stubs. At least two higher harmonics are suppressed.



# New Materials in Electrical and Electronic Engineering/ Novi Materijali (NM)

## SESSION/SESIJA NMI1

Friday/Petak, September/Sepembar, 10<sup>th</sup>, 09:00 – 11:30, Room 2/Soba 2

### Chair/Predsedavajući:

**Vesna Paunović, University of Niš, Faculty of Electronic Engineering, Serbia**  
**Nebojsa Mitrovic, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Serbia**

### NMI1.1 MÖSSBAUER SPECTROSCOPY OF IRON-BASED CHALCOGENIDES – INVITED PAPER

*Valentin Ivanovski, “Vinča” Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, Serbia*

Soon after the discovery of superconductivity in LaFeAsO with TC = 26 K in 2008, many other iron-based superconductors were synthesized. They are all based on the layers which contain iron and a pnictogen (As, P) or a chalcogen (S, Se, Te) element. Due to the connection between superconductivity and magnetism these novel unconventional high-TC superconductors have attracted tremendous interest in the scientific community. A particularly well studied is tetragonal FeSe in the PbO type structure (11 family). The improvement of TC was achieved by the intercalation of an additional layer such as perovskite-like blocks or alkaline metals into the Fe-based chalcogenide layered systems. This led to creation of new superconducting compounds,  $A_y\text{Fe}_2 - x\text{Se}_2$  (A is an alkaline element) named 122 family whose physical and structural properties are found to be very sensitive on details of the chemical composition. Unlike layered cuprate superconductors, a cationic disorder arisen from a substitution in an Fe-layer improves TC. The highest TC in the Fe-based chalcogenide superconductors is accomplished by suppression of both long range crystallographic and magnetic order. Mössbauer spectroscopy is a very useful tool for studies of structural phase transitions, structure defects, and chemical and structural inhomogeneities. This lecture is devoted to the local structure studies of  $\text{Fe}_{1-x}\text{Se}_2$ ,  $\text{K}_0.7\text{Na}_{0.1}\text{Fe}_2\text{Se}_2$ ,  $\text{KFe}_{1-x}\text{Co}_x\text{Se}_2$ , and similar Fe-based chalcogenide compounds using the Mössbauer spectroscopy.

### NMI1.2 AN OVERVIEW ON A GRAPH THEORY APPLICATIONS NEW FRONTIERS IN ELECTRONICS MATERIALS

*Vojislav V. Mitic, University of Nis, Faculty of Electronic Engineering, Serbia*  
*Branislav M. Randjelovic, University of Nis, Faculty of Electronic Engineering, Serbia*  
*Dusan Milosevic, University of Nis, Faculty of Electronic Engineering, Serbia*  
*Srdjan Ribar, University of Belgrade, Faculty of Mechanical Engineering, Serbia*  
*Ivana Radovic, Institute of Nuclear Sciences ‘VINČA’, University of Belgrade, Serbia*  
*Markus Mohr, University of Ulm, Institute of Functional Nanosystems, Ulm, Germany*  
*Hans J. Fecht, University of Ulm, Institute of Functional Nanosystems, Ulm, Germany*

This paper are new exciting results and an overview in graph theory applications on various problems in electronic materials. This opens new frontiers in this field. There are a lot of scientific efforts, especially during last few years. Our research team made very significant contribution, particularly related to calculation of parameters of BaTiO<sub>3</sub> ceramics, calculation of synthesized diamonds electrophysical parameters, modelling of microelectronic intergranular relations and use of materials in medicine, based on biomimetic. We also discuss interesting possibilities for further research.

### NMI1.3 BIOMOLECULES AND BROWNIAN MOTION

*Vojislav Mitić, Faculty of Electronic Engineering, University of Nis, Institute of Technical Sciences of SASA, Serbia*

*Bojana Markovic, Faculty of Electronic Engineering, University of Nis, Serbia*

*Sanja Aleksić, Faculty of Electronic Engineering, University of Nis, Serbia*

*Dušan Milošević, Faculty of Electronic Engineering, University of Nis, Serbia*

*Branislav Randjelović, Faculty of Electronic Engineering, University of Nis, Faculty of Teachers Education, University of Kosovska Mitrovica, Serbia*

*Ivana Ilić, Medical Faculty, Department for Mathematics and Informatics, University of Nis, Serbia*

*Jelena Manojlović, Faculty of Mechanical Engineering, University of Nis, Serbia*

*Branislav Vlahović, North Carolina Central University, USA Durham NC, United States*

Structures and different life functions of microorganisms, like motion, are based on molecular biology processes, which comprise molecular and submolecular particles. It is very important to determine relation between molecular and microorganisms levels. The aim of our research is the analysis of Brownian motion as a general phenomenon and the consequence of structures hierarchy from molecular to microorganisms level. If we approach this idea from the aspect of biomimetic correlations at the level of the alive and nonalive matter system particles, the condensed matter particles could be considered as a part of micro, nano and molecular microorganisms structures. In this research we used the experimental results of bacterial motion influenced by different energy impulses. The important goal of this research paper is to obtain significant data regarding Brownian motion in the frame of fractal nature similarities, as an integrative property of living and nonliving systems particles processes. This opens new frontiers for submicroelectronics relations within the integrated supermicro biophysical systems. This is a potential new trend in nowadays advanced research, where we integrate the knowledges of complex relations between the electrons or other particles and their clusters as joint structures in alive and condensed matter, what could be a possible direction for new microelectronics complex biodevices and integrations.

### NMI1.4 RECONSTRUCTION OF FIBER REINFORCEMENT IN EPOXY-BASED COMPOSITE

*Aleksandar Stajcic, CMTM, ICTM – National Institute of the Republic of Serbia, University of Belgrade, Belgrade, Serbia, Serbia*

*Vojislav Mitic, University of Nis, Faculty of Electronic Engineering, Serbia; ITS, SASA, Serbia*

*Cristina Serpa, ISEL - Instituto Superior de Engenharia de Lisboa do Instituto Politécnico de Lisboa, Portugal*

*Filip Veljkovic, Department of Physical Chemistry, 'VINČA' INS - National Institute of the Republic of Serbia, University of Belgrade, Serbia*

*Branislav Randjelovic, University of Nis, Faculty of Electronic Engineering; University of K. Mitrovica, Faculty of Teachers Education, Serbia*

*Ivana Radovic, Department of Physical Chemistry, 'VINČA' INS - National Institute of the Republic of Serbia, University of Belgrade, Serbia*

Polymer matrix composites (PMCs) are very attractive materials due to a possibility to achieve versatile properties by combining with ceramic or metal reinforcement in different shapes and sizes. As a result, PMCs have found application in nearly every field, from household appliances to aerospace industry. Modern microelectronic devices contain conductive polymers with fillers that enhance their electrical properties. In addition, PMCs are being used as insulators and adhesives, contributing to the long life of electronic devices. Epoxy resins are the most commonly used insulators and adhesives. In order to improve their fracture toughness, glass fibers can be used as an efficient reinforcement. However, with the purpose of designing a composite with good mechanical properties and durability, deep knowledge of microstructure is required. In addition, microstructural analysis can be used to connect shape and size of pores or reinforcement with various physical properties. Fractal nature analysis is a valuable mathematical tool that can be employed for different shapes and forms rendering. In this manner, successful design and prediction of composite's properties could be obtained. In this research, field emission scanning electron microscopy (FESEM) images were used for fractal analysis of glass fibers, with the aim of reconstructing the shape.

## NMI1.5 THE NEURAL NETWORK APPLICATION ON CERAMICS MATERIALS DENSITY

*Srdjan Ribar, University of Belgrade, Faculty of Mechanical Engineering, Serbia*  
*Vojislav V. Mitic, University of Nis, Faculty of Electronic Engineering, Serbia*  
*Branislav Randjelovic, Faculty of Electronic Engineering, University of Nis, Serbia*  
*Dusan Milosevic, University of Nis, Faculty of Electrical Engineering, Serbia*  
*Vesna Paunovic, University of Nis, Faculty of Electrical Engineering, Serbia*  
*Hans J. Fecht, University of Ulm, Institute of Functional Nanosystems, Ulm, Serbia*  
*Branislav Vlahovic, North Carolina Central University, (NCCU), Durham, North Carolina USA, Serbia*

In this research back propagation neural network (BP) was applied on ceramics material samples, consolidated by sintering data obtained in analyzed experiment in a specific way. The main characteristic of BP is that it is capable to perform arbitrarily input-output data mapping due to large set of adjustable coefficients called weights. Desired mapping is possible to achieve if coefficients are set to proper value and this procedure is called training. At the beginning of training process weights are set to random values. Error is defined as a difference between desired and actual network output and weight coefficients have a contribution in generating error. Within experimental from material density values sintering results, measured on a surface, we investigate a possibility to calculate density within sintered structure. In this case BP training procedure is used as a tool to spread values measured on a sample surface – density. In this investigation network errors are replaced with density values obtained in ceramics sintering process. We successfully performed this neural network application novelty in ceramics material sciences within sintering process for the case  $r=5.4 \times 10^3 [\text{kg/m}^3]$ .

## NMI1.6 CHARACTERISTIC ENERGY OF $\text{Ar}^+$ IN $\text{BF}_3$ GASES AND $\text{Ar/BF}_3$ MIXTURES

*Željka Nikitović, Institute of Physics, University of Belgrade, Serbia*

In this paper we present most probable reactions of  $\text{Ar}^+$  ion with  $\text{Ar/BF}_3$  mixtures. Appropriate gas phase enthalpies of formation for the products were used to calculate scattering cross section as a function of kinetic energy. These data are needed for modeling in numerous applications of technologically important  $\text{BF}_3$  discharges. Results for transport parameters, specially characteristic energy as a function of  $E/N$  ( $E$ -electric field;  $N$ -gas density) were obtained by using the Monte Carlo technique

## NMI1.7 STRUCTURAL CHARACTERIZATION OF $\text{La}(\text{Mg}_{1/2}\text{Ti}_{1/2})\text{O}_3$ (LMT) PEROVSKITE FOR MOBILE COMMUNICATIONS

*Kouros Khamoushi, Natural Science, Tampere University, Finland., Finland*  
*Vojislav Mitić, University of Niš, Faculty of Electronic Engineering, Serbia*  
*Jelena Manojlović, University of Niš, Faculty of Mechanical Engineering, Serbia*  
*Vesna Paunović, University of Niš, Faculty of Electronic Engineering, Serbia*  
*Goran Lazović, University of Belgrade, Faculty of Mechanical Engineering, Serbia*

The phase group and structure properties of  $\text{La}(\text{Mg}_{1/2}\text{Ti}_{1/2})\text{O}_3$  (LMT) ceramics, prepared via the mixed oxide route, were examined in this research. A single-phase  $\text{La}(\text{Mg}_{1/2}\text{Ti}_{1/2})\text{O}_3$  ceramic were produced at different sintering temperature from  $1250^\circ\text{C}$  to  $1675^\circ\text{C}$ . The heating rate was  $25^\circ\text{C}$  to the sintering temperature and the cooling rate from  $2^\circ\text{C}$  per minute to room temperature. The XRD analysis determined that LMT ceramics have a cubic crystal structure with a lattice parameter  $a = 0.392\text{ nm}$ . The theoretical density of this ceramics is  $6.0846\text{ g/cm}^3$ . These materials must be sintered from  $1550$ - $1675^\circ\text{C}$  to achieve a sintering density of about 99% of theoretical density. At a temperature lower than  $1500^\circ\text{C}$  a density was 93% of theoretical density. The temperature coefficient of resonant frequency for LMT was  $-72\text{ MK}^{-1}$ , and the Quality factor was 34000 at a frequency of  $8.07\text{ GHz}$ .

## NM1.1 UTICAJ JONA RETKIH ZEMALJA (Er, Yb, Ho) NA KARAKTERISTIKE BaTiO<sub>3</sub> KERAMIKE

*Vesna Paunović, Univerzitet u Nišu, Elektronski fakultet, Serbia*

*Vojislav Mitić, Univerzitet u Nišu, Elektronski fakultet, Serbia*

*Zoran Prijić, Univerzitet u Nišu, Elektronski fakultet, Serbia*

U ovom radu, oksidi retkih zemalja, Er<sub>2</sub>O<sub>3</sub>, Yb<sub>2</sub>O<sub>3</sub> i Ho<sub>2</sub>O<sub>3</sub>, su korišćeni kao materijali za dopiranje barijum-titanatne keramike. BaTiO<sub>3</sub> keramika dopirana je sa 0.01, 0.5 i 1.0 wt% Er, Yb ili Ho i pripremljena uobičajenim postupkom sinterovanja u čvrstom stanju. Uzorci su sinterovani na 1320 °C četiri sata. SEM analiza je pokazala da se u uzorcima BaTiO<sub>3</sub> dopiranim jonima retkih zemalja niskih koncentracija (0.01 wt%), veličina zrna kretala između 10 i 30 um. Sa povećanjem koncentracije dopanata od 1.0 wt %, abnormalni rast zrna je zaustavljen, a veličina zrna se kretala između 2-10 um. Merenja dielektrične konstante i dielektričnih gubitaka u zavisnosti od frekvencije i temperature vršena su u cilju uspostavljanja korelacije između mikrostrukture i dielektričnih svojstava dopirane BaTiO<sub>3</sub> keramike. Amfoterno ponašanje jona retkih zemalja dovodi do povećanja dielektrične konstante i smanjenja dielektričnih gubitaka u odnosu na nedopiranu BaTiO<sub>3</sub> keramiku. Ispitivana je i temperaturna zavisnost dielektrične konstante u zavisnosti od vrste i količine dopanata.

## NM1.2 ISPITIVANJE STRUKTURNIH SVOJSTAVA LEGURE FECOV METODOM SKENIRAJUĆE ELEKTRONSKE MIKROSKOPIJE - SEM

*Borivoje Nedeljkovic, FTN CACAK, Serbia*

*Vladimir Pavlovic, Institut tehnickih nauka SANU, Beograd, Serbia*

*Nina Obradovic, Institut tehnickih nauka SANU Beograd, Serbia*

*Nebojsa Mitrovic, FTN CACAK, Serbia*

U radu su ispitivani strukturna svojstva legure 49Fe49Co2V proizvedene PIM/MIM tehnologijom, tako što je polazni granulat pripremljen mešanjem FeCoV praha sa niskoviskoznim vezivom. Nakon brizganja sirovi uzorci su najpre tretirani rastvaračem a zatim i termički s istim ciljem odstranjivanja veziva. MIM tehnologija je završena visokotemperaturnim sinterovanjem tokom 3,5 sata na temperaturama od 1370 OC do 1460 OC u atmosferi vodonika, kojim se obezbeđuju potrebne magnetne i mehaničke karakteristike. Strukturna svojstva veličine čestica D<sub>max</sub>, Feret X, Feret Y su ispitivana u zavisnosti od temperature sinterovanja.

## NM1.3 ВИСОКОФРЕКВЕНТНА ИСПИТИВАЊА МАГНЕТОИМПЕДАНСНОГ ЕФЕКТА COFESiB АМОРФНЕ ЖИЦЕ

*Jelena Orelj, FTN CACAK, Serbia*

*Nebojsa Mitrovic, FTN CACAK, Serbia*

У раду је приказан магнетоимпедансни (МИ) ефекат код жице аморфне легуре CoFeSiB у опсегу фреквенција 1 MHz ÷ 5 MHz (@ H<sub>max</sub> » 463 A/m). Максимални МИ–однос износи око 45% @ 1 MHz, уз промену облика криве ΔZ(H)/Z при фреквенцијама вишим од 1 MHz. Из облика криве са константним смањењем МИ–односа при 1 MHz, са даљим повећањем фреквенције се региструје максимум који одговара пољу магнетне анизотропије H<sub>k</sub>. При повећању фреквенције регистровано је и повећање поља магнетне анизотропије H<sub>k</sub>.

# **Nuclear engineering and technology/ Nuklearna tehnika (NT)**

## **SESSION/SESIJA NT11+NT1**

Thursday/Četvrtak, September/Septembar, 09<sup>th</sup>, 09:00 – 11:30, Room 3/Soba 3

### **Chair/Predsedavajući:**

**Koviljka Stanković, University of Belgrade – School of Electrical Engineering, Serbia**

### **NT11.1 RADIOACTIVE WASTE MANAGEMENT: CONSTRUCTION AND DEMOLITION DEBRIS IN GEOPOLYMERS**

*Ivana Jelić, Vinca Institute of Nuclear Sciences, Serbia*

*Marija Šljivić-Ivanović, Vinca Institute of Nuclear Sciences, Serbia*

*Tatjana Miljojčić, Vinca Institute of Nuclear Sciences, Serbia*

*Milica Ćurčić, Vinca Institute of Nuclear Sciences, Serbia*

*Slavko Dimović, Vinca Institute of Nuclear Sciences, Serbia*

Construction and demolition debris (C&DD) is one of the fastest-growing waste streams due to the global economic development and urbanization process. Therefore, developing more attractive and inexpensive methods and creating more valuable conventional and novel technologies that could more efficiently use these wastes and solve possible environmental problems, especially radioactive waste. The most widespread and economically viable solution for the reuse of C&DD today is civil engineering and the road industry. Also, there are several possible ways to use C&DD in geopolymers as recycled aggregates, activating components (precursors) depending on the composition, and as a hybrid system: with some aluminosilicate material that has better geopolymerization capacity or ordinary Portland cement. This use of C&D enables the synthesis of a wide range of matrices for the immobilization of radionuclides.

### **NT11.2 A STRATEGIC MEANS OF HYBRID WARFARE**

*Milica Ćurčić, “Vinca” Institute of Nuclear Sciences - National Institute of Republic of Serbia, University of Belgrade, Serbia*

*Slavko Dimović, “Vinca” Institute of Nuclear Sciences - National Institute of Republic of Serbia, University of Belgrade, Serbia*

*Ivan Lazović, “Vinca” Institute of Nuclear Sciences - National Institute of Republic of Serbia, University of Belgrade, Serbia*

The modern security environment is undergoing a profound transformation. This transformation has been shaped by the emergence of new patterns of conflict and cooperation among state and non-state actors as well as the spread of globalization and new technologies. Also, the development of a new breed occurred, characterized by a combination of warfare methods and usage of different means of warfare. In the constellation of new wars, a hybrid wars stand out as a war that combines different strategies of warfare to achieve synergistic effects. The aim of the article is to analyze and describe characteristic of both non-state and state hybrid warfare, as well as the key elements that constitute strategic means of hybrid warfare. The usage of information weapons, cyber sphere and psychological means, in combination with conventional weapons of war, become main features of modern conflict. Modern technologies are the main factor that influenced and transformed warfare and their usage permeates every activity in hybrid war.

### NT11.3 STANDARD AND VALIDATED METHOD FOR DETERMINATION OF TRITIUM ON LIQUID SCINTILLATION SPECTROMETER

*Marija Janković, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*  
*Nataša Sarap, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*  
*Gordana Pantelić, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*  
*Jelena Krneta Nikolić, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*  
*Milica Rajačić, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*  
*Ivana Vukanac, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*  
*Dragana Todorovic, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*

Tritium concentrations in water samples were analyzed. The aim is to compare methods: standard method (direct method): according to ASTM D 4107-08 and validated method: which applies electrolytic enrichment. Low level tritium concentration in natural waters required measurement after enrichment. One set of samples, which contain 16 samples including spike water were enrichment and compared with 4 samples measured by direct method. For this analysis liquid scintillation spectrometer was using. In general, analysis with enrichment is more applicable for samples with low activity. Also, validated method with enrichment reduced minimum detectable concentration.

### NT11.4 HPGE DETECTOR EFFICIENCY OPTIMIZATION FOR THE ATYPICAL MEASUREMENT GEOMETRY OF SIMULATED AEROSOL FILTERS

*Jelena Krneta Nikolić, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*  
*Ivana Vukanac, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*  
*Milica Rajačić, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*  
*Dragana Todorović, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*  
*Gordana Pantelić, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*  
*Marija Janković, Institute for Nuclear Sciences Vinča, National Institute of Republic of Serbia*

Gamma spectrometry is widely used method of choice for measurement of environmental samples conducted during monitoring of the environment and contamination control, as well as measurement of radionuclide content in various materials. However, one of the main challenges in this method of spectrometry is the determination of detection efficiency for different energies, different source-detector geometries and different composition of samples. This task is defined as an efficiency calibration of the detector. When using a commercial calibration sources is not possible, or the available sources are not adequate, the optimization of the efficiency calibration has to be performed. In this paper, the results of the optimization of efficiency calibration for the atypical geometry and composition of the simulated aerosol samples, measured within the Proficiency tests organized by International Atomic Energy Agency (IAEA), performed using EFFTRAN efficiency transfer software, will be presented and discussed.

### NT1.1 POSLEDICA MERENJA BRZIH NAPONA KEROVIM EFEKTOM U POLJU GAMA ZRAČENJA

*Nemanja Arandelović, Tehnološko-metalurški fakultet, Univerzitet u Beogradu, Srbija, Serbia*  
*Dusan Nikezic, Vinča Institute of Nuclear Sciences, Serbia*  
*Dragan Brajović, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Serbia*  
*Uzahir Ramadani, Vinča Institute of Nuclear Sciences, Serbia*

U ovom radu se razmatra mogućnost merenja elektronskog impulsa iz elektronskog generatora za zagrevanje plazme elektrooptičkom metodom. Eksperimenti se vrše primenom Kerovog efekta na modelu elektronskog generatora. Kerov efekat pokazuje izuzetno dobre karakteristike za merenje impulsa nanosekundne brzine. Međutim, dobijeni rezultati pokazuju da te njegove karakteristike znatno kviri gama zračenje u dinamičkom stanju kao i apsorbovana doza gama zračenja. Kada se tome doda i jednostavnost merenja kapacitivnom sondom može se zaključiti da Kerov elektrooptički efekat nije preporučljiv za merenje u fuzionim eksperimentima.

# Computing and information engineering/ Računarska tehnika i informatika (RT)

## SESSION/SESIJA RTI1:

Thursday/Četvrtak, September/Septembar, 09<sup>th</sup>, 09:00 – 11:30, Room 1/Soba 1

### Chair/Predsedavajući:

**Igor Tartalja, University of Belgrade, School of Electrical Engineering, Serbia**

#### RTI1.1 FILE SYSTEM PERFORMANCE COMPARISON OF NATIVE OPERATING SYSTEM AND DOCKER CONTAINER-BASED VIRTUALIZATION

*Borislav Dorđević, Institute Mihailo Pupin, University of Belgrade, Serbia*

*Darko Gojak, VISER - School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

*Nikola Davidović, University of East Sarajevo, Faculty of Electrical Engineering, Bosnia and Herzegovina*

*Valentina Timcenko, Institute Mihailo Pupin, University of Belgrade, Serbia*

The aim of this paper is to examine and compare the file system capabilities of container virtualization and of the native host. Different virtualization categories are mentioned with the focus on OS level type. We have described the importance of container virtualization and its contribution to virtualization popularization. Also, the paper contains a detailed description of the Docker container-based virtualization, its mode of operation, as well as the advantages and disadvantages it possess. Since the main purpose of this work is to measure the host and Docker file system throughput, one of the best open-source benchmarks is chosen and presented - FileBench, through which all tests were performed. With practical example, we have shown the file system performance comparisons considering Docker containers and host physical machine.

#### RTI1.2 PERFORMANCE COMPARISON OF NATIVE HOST VS. ESXI HYPERVISOR-BASED VIRTUALIZATION

*Borislav Dorđević, Institute Mihailo Pupin, University of Belgrade, Serbia*

*Srdan Milenković, VISER - School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

*Nikola Davidović, University of East Sarajevo, Faculty of Electrical Engineering, Bosnia and Herzegovina*

*Valentina Timčenko, Institute Mihailo Pupin, University of Belgrade, Serbia*

The main objective of this paper is performance comparison of hypervisor-based virtualization with VMware ESXi virtual machines and native host machine. From all performance classes, for the needs of this research we have chosen the evaluation of the file system performance. The measurements are carried out under equivalent conditions and by a unique test method, using the Filebench software, which guarantees equality and independence from the impact of hardware and operating system characteristics. As the base operating system we have used CentOS 7.7 with the latest updates, while ESXi 6.7 was used as the hypervisor. Performances are compared for the native host machine and ESXi server with one, two and three virtual machines (VM) running simultaneously. We have also analysed the expected behaviours, verified the assumption with Filebench testing software, and provided the concluding remarks for this papers research topic.

#### RTI1.3 ESXI AND PROXMOX: FILESYSTEM PERFORMANCE COMPARASION FOR TYPE-1 HYPERVISORS

*Borislav Dorđević, Institute Mihailo Pupin, University of Belgrade, Serbia*

*Valentina Timčenko, Institute Mihailo Pupin, University of Belgrade, Serbia*

*Nenad Nedeljković, VISER, School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

*Nikola Davidović, University of East Sarajevo, Faculty of Electrical Engineering, Bosnia and Herzegovina*

This paper presents the comparison of two representatives of type 1 hypervisors: Proxmox VE and VMware ESXi. The measurements are carried out on the same server and under the equivalent

conditions, with the Linux Ubuntu 20.10 as the guest operating system using the Filebench 1.5-alpha1 software. The goal of this paper is to show an impact of different number of virtual machines on the performances of various file system and highlight the best combination. The results have been illustrated in graphical form.

#### RTI1.4 DESIGN OF A NETWORK TOPOLOGY USING CISCO NSO ORCHESTRATOR

*Mioljub Jovanovic, University of Westminster, United Kingdom*

*Milan Cabarkapa, University of Belgrade, Serbia*

*Djuradj Budimir, University of Westminster, United Kingdom*

In this paper, the mismatch problem between a network service and its monitoring are clearly addressed and discussed. We then proposed the approach how to solve this problem. Applying the proposed approach, we are achieved the telemetry efficiency ratio parameter greater than 40. All tests are performed in real experimental conditions using CISCO NSO orchestrator for this purpose which is used for designing of network topology.

#### RTI1.5 IMPLEMENTATION OF SMOOTH STREAMING PROTOCOL THROUGH A GENERALIZED SOFTWARE FRAMEWORK

*Miroslav Suša, RT-RK Institute for Computer Based Systems, Serbia*

*Ilija Bašičević, Faculty of Technical Sciences, Serbia*

Adaptive streaming is a technology for transmitting multimedia content over a network such as the Internet. This way the content is available at any time which has brought big changes. One of the many streaming technologies is Smooth Streaming. In addition to the transmission of content via one of the protocols, it is necessary to ensure its reproduction. In this paper, the implementation of the Smooth Streaming protocol within a single media player is presented. The implementation was performed through a generalized software framework, which will also be discussed. The role of the framework is to facilitate the integration of the remaining adaptive streaming protocols into the media player.

#### RTI1.6 IMPLEMENTATION OF THE GDPR COMPLIANT DATA HANDLING FOR SMART HOME SOLUTION

*Sandra Bugarin, OBLO Living, Serbia*

*Sandra Ivanović, Faculty of Technical Sciences, Serbia*

*Marija Antić, Faculty of Technical Sciences, Serbia*

The amount of personal data collected and shared in the Internet of Things (IoT) is causing increasing concerns regarding the user privacy in IoT. The recently introduced General Data Protection Regulation (GDPR) is a legal framework that sets guidelines for the collection and processing of personal information and aims to strengthen user rights. In order to comply with the GDPR requirements, the existing smart home system is extended with the cloud service, responsible for user consent management and appropriate data handling. The architecture of the solution, as well as the results of functional and performance testing are presented in this paper.

#### RTI1.7 THE IMPACT OF FAT-TREE TOPOLOGY ON ONOS AND RYU SDN CONTROLLER PERFORMANCE

*Danijel Čabarkapa, Academy of Professional Studies Šabac, Department of Medical and Business-Technological Studies, Serbia*

*Petar Pavlović, Academy of Professional Studies Šabac, Department of Medical and Business-Technological Studies, Serbia*

*Dejan Rančić, University of Niš, Faculty of Electronic Engineering, Serbia*

*Miodrag Miličević, Academy of Professional Studies Šabac, Department of Medical and Business-Technological Studies, Serbia*

Software Defined Network (SDN) is an important technology that enables a new approach in how we develop and manage networks. SDN divides the data plane and control plane and promotes logical centralization of network control so that the controller can schedule the data in the network effectively through OpenFlow protocol. The performance and capabilities of the controller itself are important. The



impact of network topology type on controller performance can be very significant. In order to have better communication in SDN, it is essential to have an analysis of the performance of specific network topologies. In this paper, we simulate ONOS and Ryu controllers and compare their different network parameters under the proposed complex custom Fat-Tree topology. A network topology has been designed using a Mininet emulator, and the code for topology is executed in Python. From the throughput, packet transmission rate, and latency analysis, the ONOS controller displayed better results than Ryu, showing that it can respond to requests more efficiently under complex SDN topologies and traffic loads. On the contrary, Ryu provides better results for the less complex SDN networks.

#### RTI1.8 SNORT IDS SYSTEM VISUALIZATION INTERFACE

*Nadja Gavrilovic, Faculty of Electronic Engineering, University of Niš, Serbia*

*Vladimir Ciric, Faculty of Electronic Engineering, University of Niš, Serbia*

*Nikola Lozo, Faculty of Electronic Engineering, University of Niš, Serbia*

Over the past decades, the rapid Internet development and the growth in the number of its users have raised various security issues. Despite numerous available security tools, the exchange of data over the Internet is becoming increasingly insecure. For this reason, it is of great importance to ensure the security of the network in order to enable the safe exchange of confidential data, as well as their integrity. One of the most important components of network attack detection is an Intrusion Detection System (IDS). Snort IDS is a widely used intrusion detection system, which logs alerts after detecting potentially dangerous network packets. The next step in successful network protection is the analysis of logged alerts in search of deviations from normal traffic that may indicate an intrusion. The goal of this paper is to design and implement a visualization interface that graphically presents alerts generated by Snort IDS, classifies them according to the most important attack parameters, and allows the users to easily detect possible traffic irregularities. An environment in which the system has been tested in real-time is described, and the results of attack detection and classification are given. One of the detected attacks is analyzed in detail, as well as the method of its detection and its possible consequences.

#### RTI1.9 VISUALIZATION OF MICROSCOPIC MORPHOLOGICAL CHARACTERISTICS USED FOR DETERMINATION OF INFECTIOUS MOLDS

*Mina Milanovic, Faculty of Electronic Engineering - University of Nis, Serbia*

*Aleksandar Milosavljević, University of Niš, Faculty of Electronic Engineering, Serbia*

*Marina Randelović, University of Niš, Medical faculty, Serbia*

Invasive fungal infections (IFI) and systemic fungal infections (SFI), caused by molds are on the rise, based on data from literature. Diagnostics of those infections can sometimes be inefficient; they require a longer period of time in laboratory procedures and sometimes may lead to late diagnosis or misdiagnosis, which can result in patient's critical condition or even mortality. The goal of this research is to develop a neural network model that will perform identification of molds, and thus accelerate the process of diagnostics. A classifier has been developed, using an EfficientNet-B1 deep convolutional neural network (CNN) and sample images obtained at the Department of Microbiology and Immunology, Medical faculty, University of Niš, Serbia, archives. We applied Grad-CAM visualization to determine morphological characteristics used by the model to classify samples.

## SESSION/SESIJA RTI2:

Thursday/Četvrtak, September/Septembar, 09<sup>th</sup>, 15:00 – 17:00, Room 1/Soba 1

### **Chair/Predsedavajući:**

**Ivan Milentijevic, University of Nis, Faculty of Electronic Engineering, Serbia**

#### **RTI2.1 DISTRIBUTED PROCESSING OF NETWORK PACKETS IN HADOOP FOR NETWORK INTRUSION DETECTION**

*Vladimir Ciric, University of Nis, Faculty of Electronic Engineering, Serbia*

*Nadja Gavrilovic, University of Nis, Faculty of Electronic Engineering, Serbia*

*Ivan Milentijevic, University of Nis, Faculty of Electronic Engineering, Serbia*

Intrusion Detection is de facto standard for network security monitoring. However, it requires a lot of processing due to the increased volume of network traffic, on the one hand, and the large number of malicious signatures that must be inspected, on the other. In such cases, distributed processing frameworks, such as Hadoop, can be successfully used. The drawback is that they usually require preprocessing and reformatting of the data in a suitable format. In this paper, we propose an algorithm for distributed processing of captured network packets on Hadoop for intrusion inspection, including distributed network packet decoding. The proposed algorithm deals with the problem of splitting the sensitive data to different nodes in a distributed environment. It will be shown that the proposed algorithm significantly shortens the IDS execution time.

#### **RTI2.2 FREELANCING BLOCKCHAIN: A PRACTICAL CASE-STUDY OF TRUST-DRIVEN APPLICATIONS DEVELOPMENT**

*Milan Radosavljevic, University of Nis, Faculty of Electronic Engineering, Serbia*

*Aleksandar Pesic, University of Nis, Faculty of Electronic Engineering, Serbia*

*Nenad Petrovic, University of Nis, Faculty of Electronic Engineering, Serbia*

*Milorad Tosic, University of Nis, Faculty of Electronic Engineering, Serbia*

Nowadays, a large amount of work is done by freelancers across various areas – from graphical design and music composition to data input and software development. However, many issues appear due to participation of several third parties together with different rules and policies imposed by different platforms. On the other side, the emerging blockchain technology provides the execution of transactions in a trustable, decentralized, but still transparent manner. In this paper, we demonstrate a case-study where blockchain is adopted to eliminate the barriers and make freelancing more convenient and profitable at the same time. As an outcome, a proof-of-concept implementation of blockchain-based freelancing platform relying on Ethereum and Solidity smart contracts is presented that provides practical pointers for trust-driven applications development.

#### **RTI2.3 COMBINED ADAPTIVE LOAD BALANCING ALGORITHM FOR PARALLEL APPLICATIONS**

*Luka Filipović, Univerzitet Donja Gorica, Montenegro*

*Božo Krstajić, Univerzitet Crne Gore, Montenegro*

*Tomo Popović, Univerzitet Donja Gorica, Montenegro*

Development and improvement of efficient techniques for parallel tasks scheduling on multiple cores processors is one of the key issues encountered in parallel and distributed computer systems. The purpose of process distribution improvement in parallel applications is increased system performance, reduced application execution time, reduced losses and increased resource utilization. This paper presents combined adaptive load balancing algorithm based on domain decomposition and master-slave algorithms and its core scheduling adaptive mechanism that handles load redistribution according obtained and analyzed data. Selection of distribution algorithm, based on collected parameters and previously defined conditions, proved to deliver increased performances and reduced imbalance. Results of simulations confirm better performance of proposed algorithms compared to the standard algorithms reviewed in this paper.

## RTI2.4 A TOOL FOR SENTENCE SYNTAX STRUCTURE MARKUP FOR THE SERBIAN LANGUAGE

*Teodora Dorđević, University of Nis, Faculty of Electronic Engineering, Serbia*  
*Suzana Stojković, University of Nis, Faculty of Electronic Engineering, Serbia*

Syntax analysis is an important part of natural language processing. The biggest challenge to defining a natural language syntax analyzer is the inability to define unambiguous formal grammars that describe the language. Because of this, rule-based syntax analyzers need to be enhanced using statistics to allow us to predict which syntax tree is most likely. In order to do this, a corpus of tagged sentences in the target language is needed. The creation of this corpus is long and tedious work. Because of this, this paper implements a visual tool for creating such a corpus for the Serbian language. A component of this tool is the syntax analyzer, which generates all the possible syntax trees based on the defined grammar such that an expert may choose one of them. The expert may also create entirely new syntax trees.

## RTI2.5 PERFORMANCE COMPARISON OF HOMOMORPHIC ENCRYPTION SCHEME IMPLEMENTATIONS

*Goran Dorđević, AET Europe, ETF Beograd, Netherlands*  
*Milan Marković, Panevropski Univerzitet Apeiron Banja Luka, Serbia*  
*Pavle Vuletić, ETF Beograd, Serbia*

Homomorphic Encryption allows third party to receive encrypted data and perform arbitrarily computations on that data while it remains encrypted, despite not having the secret decryption key. This enables many new secure applications in cloud environments. For a long time, a key issue with the homomorphic encryption was its low performance which made it unusable in production environments. Advances in the last ten years in the field of homomorphic encryption resulted in several new schemes and software libraries which implement them. These homomorphic schemes have improved performance, but there is still a question whether the improvements would justify their use in production environments. In this paper we evaluated features and performance of several new homomorphic encryption mechanisms: BGV, BFV and CKKS.

## RTI2.6 COMPARISON OF MESSAGE QUEUE TECHNOLOGIES FOR HIGHLY AVAILABLE MICROSERVICES IN IOT

*Marko Milosavljevic, ObloLiving, Serbia*  
*Milica Matic, ObloLiving, Serbia*  
*Neven Jovic, ObloLiving, Serbia*  
*Marija Antic, ObloLiving, Serbia*

Internet of Things (IoT) solutions connect large numbers of devices, which generate various data and control messages asynchronously. In the IoT system cloud, these messages need to be queued in order to control the processing load and prevent the overload in cases of traffic bursts. On the other hand, one of the requirements the IoT cloud needs to fulfill is the high availability. Therefore, multiple instances of services accepting and processing the messages generated by the devices are needed. There are various message queue technologies available today, but they all have their limitations. In this paper, we compare the performance of Apache Kafka and RabbitMQ in the scenario of the highly available IoT cloud data processing.

## RTI2.7 MODELING THE ATP TOUR MATCHES: A SOCIAL NETWORKS ANALYSIS APPROACH

*Balša Knežević, University of Belgrade, School of Electrical Engineering, Serbia*  
*Miloš Obradović, University of Belgrade, School of Electrical Engineering, Serbia*  
*Predrag Obradović, University of Belgrade, School of Electrical Engineering, Serbia*  
*Marko Mišić, University of Belgrade, School of Electrical Engineering, Serbia*

Professional men's tennis is a demanding sport which greatly benefits from various approaches to performance analysis. More specifically, a complex network theory can be used to model and explain the dynamics of players and tournaments, based on the recorded matches. In this paper, played matches are used to model a social interaction between players. Several undirected weighted networks are

constructed to model the ATP tour matches from 2018 to 2020. Moreover, the three most dominant players on the tour (the “Big Three”) were observed and analyzed using ego networks. The chosen time frame further allowed for the exploration of impact of COVID-19 on the dynamics of the ATP tour. Different network properties were explored, such as small world phenomenon, core-periphery model applicability, community structure, and the rich club phenomenon. Our results based on network theory approach showed that analyzed networks expose similar topological properties, despite the lower numbers of tournaments held in the year 2020.

## **RTI2.8 COMPARATIVE ANALYSIS OF INTRA-BOARD SYNCHRONOUS SERIAL COMMUNICATION INTERFACES**

*Predrag Petronijevic, Vlatacom Institute of High Technologies, Serbia*

*Vladimir Kuzmanovic, Faculty of Mathematics, University of Belgrade, Serbia*

Designing custom made hardware for special purposes is a challenging process. During the development it is essential to take into consideration the required performance of the device, component availability on the market as well as the final price of the developed and assembled product. Almost every modern hardware consists of various sensors, memories, AD/DA converters and a microcontroller to control and manage the interaction off all those devices. Based on the purpose of the device being developed, the engineer has to make a decision on the components that will be used in the final product. For this decision to be justifiable, the engineer needs to have a very high level of knowledge regarding the intricate world of interfaces required to establish the intercommunication of the components inside the device. Modern sensors, memories and AD/DA converters usually require some form of high speed serial interface, synchronous or asynchronous. In this paper we will analyze the three most commonly used serial synchronous communication interfaces: I2C, SPI and SPORT. Also, we will explain the hardware and software properties and limits of every mentioned synchronous serial interface. Finally, benefits and drawbacks of the chosen communication interfaces will be considered and conclusions drawn.

## **SASSION/SESIJA RT1:**

Thursday/Četvrtak, September/Septembar, 09<sup>th</sup>, 17:15 – 18:45, Room 1/Soba 1

### **Chair/Predsedavajući:**

**Ivan Milentijevic, University of Nis, Faculty of Electronic Engineering, Serbia**

## **RT1.1 APLIKACIJA ZA DEMONSTRACIJU XSS SIGURNOSNIH PROPUSTA**

*Katarina Simić, Elektrotehnički fakultet - Univerzitet u Beogradu, Serbia*

*Žarko Stanisavljević, Elektrotehnički fakultet - Univerzitet u Beogradu, Serbia*

XSS (eng. Cross-site scripting) je jedna od najčešćih ranjivosti veb aplikacija uprkos tome što postoji veliki broj različitih mehanizama zaštite. U ovom radu prikazana je implementacija jedne ranjive aplikacije u okviru koje je moguće demonstrirati različite tipove XSS sigurnosnih propusta, kao i načina njihove zloupotrebe, ali i eliminisanja. Aplikacija se može koristiti kao edukativno sredstvo za praktičnu obuku softverskih inženjera u zatvorenom i bezbednom okruženju.

## **RT1.2 SQLITRAINER - SISTEM ZA UČENJE O SQLI SIGURNOSNIM PROPUSTIMA U APLIKACIJAMA**

*Djordje Madic, Zuhlke Engineering d.o.o, Serbia*

*Zarko Stanisavljevic, Elektrotehnicki fakultet - Univerzitet u Beogradu, Serbia*

Sigurnosni propusti u aplikacijama koji nastaju prilikom njihovog razvoja i ostaju nedetektovani u produkcijom okruženju mogu dovesti do narušavanja integriteta, poverljivosti i dostupnosti takvih aplikacija. SQLiTrainer predstavlja skup ranjivih aplikacija kojima se mogu demonstrirati različite vrste SQLi (eng. SQL injection) ranjivosti. U radu je opisan način implementacije SQLiTrainer sistema i dati su primeri na koji način se sistem može iskoristiti za praktičnu obuku programera. Sistem je uspešno korišćen za izvođenje laboratorijskih vežbi na predmetu Zaštita računarskih sistema i mreža na Elektrotehničkom fakultetu u Beogradu.

### RT1.3 JEDNO RJEŠENJE POSREDNIKA U SISTEMU USLOVNOG PRISTUPA DIGITALNE TELEVIZIJE

*Radenko Banović, Faculty of Technical Sciences, Serbia*

*Ilija Basicovic, Faculty of Technical Sciences, Serbia*

*Nemanja Lazukić, Institut RT-RK, Serbia*

Postoje dvije vrste TV (televizijske) usluge u domenu pretplate: javna (svima dostupan sadržaj za koji nije potrebna pretplata) i pretplatnička TV usluga (TV sadržaj je dostupan samo pretplaćenim korisnicima). Da bi pretplatnička TV usluga imala smisla potrebno je zaštititi TV sadržaj cijelim prenosnim putem. Postoji nekoliko modela zaštite pretplatničkog TV sadržaja, a jedan od njih je CAS (eng. Conditional Access System). Kompanija Widevine je kreirala rješenje sistema uslovnog pristupa (CAS) takvo da je besplatno za sve operatere. Da bi operateri mogli upravljati korisnicima i sadržajem, potrebno je implementirati korisničku upravljačku logiku sistema. U ovom radu je predstavljeno jedno rješenje softverskog posrednika (eng. Proxy) u kome je realizovana korisnička upravljačka logika sistema uslovnog pristupa u Widevine CAS sistemu.—Conditional Access System; Proxy; Digital Television;

### RT1.4 JEDNO RJEŠENJE ECM GENERATORA

*Radenko Banović, Faculty of Technical Sciences, Serbia*

*Ilija Basicovic, Faculty of Technical Sciences, Serbia*

*Ksenija Popov, Institut RT-RK, Serbia*

*Milenko Maksić, Institut RT-RK, Serbia*

Zaštita televizijskog sadržaja predstavlja jedan od najvećih izazova u industriji digitalne televizije usljed sve manjeg broja televizijskih kanala čije se gledanje ne naplaćuje. Da bi omogućili naplaćivanje televizijskog sadržaja korisnicima, potrebno je zaštititi televizijski sadržaj cijelim prenosnim putem. Najkorišteniji model zaštite živog televizijskog sadržaja je CAS (eng. Conditional Access System). CAS model podrazumijeva postupak zaštite video i audio sadržaja skremblovanjem koje ima za cilj sprječavanje neovlaštene reprodukcije audio i video sadržaja. Kontrolne riječi kojima je izvršeno skremblovanje se prenose istim prenosnim kanalom kao i skremblovani sadržaj u okviru ECM (eng. Entitlement Control Message) poruke ali u enkriptovanom obliku. Kompanija Widevine je realizovala sopstveni CAS ekosistem potpuno besplatan za sve korisnike. U ovom radu je predstavljeno jedno rješenje ECM generatora u Widevine CAS sistemu.

### RT1.5 JEDNO RJEŠENJE ANALIZE I PRIKAZA KONTROLNIH TAČAKA DEFINISANIH PODEŠAVANJEM AUTOSAR NADZORNOG ČASOVNIKA

*Ivana Tesevic, RT-RK, Serbia*

*Dejan Bokan, RT-RK, Serbia*

*Bogdan Pavkovic, RT-RK, Serbia*

*Branko Milosevic, RT-RK, Serbia*

Razvojem automobilske industrije i softvera unutar nje kao tehnička posljedica javila se potreba za obaveznom integracijom zaštitnih mehanizama u ugrađenim jezgrima operativnog sistema. Jedan od osnovnih mehanizama za zaštitu sistema jeste nadzorni časovnik (eng. watchdog, WDG). Ova komponenta ima za cilj da nadgleda sve ostale komponente pokrenute od strane raspoređivača i time omogućiti bezbjedan rad sistema. Kako je probleme koje nadzorni časovnik prijavljuje relativno teško ispratiti i analizirati u stvarnom sistemu, došlo se do ideje da se oponašarad komponente nadzornog časovnika na računarsu istim ulaznim parametrima kao u živom sistemu. U ovom radu je dato rješenje za simulaciju mehanizama nadgledanja sistema definisane AUTOSAR arhitekture. Simulacijom je omogućeno da se minimalizuju odstupanja, predvide greške u sistemu i olakšava analiza. Rad može doprinijeti bržem razvoju sistema jer omogućava da se prije implementacije predvide greške koje će se desiti u sistemu.

# Robotics and Flexible Automation

## Robotika i fleksibilna automatizacija/(RO)

### SESSION/SESIJA ROI1

Friday/Petak, September/Septembar, 10<sup>th</sup>, 17:15 – 18:45, Room 1/Soba 1

#### Chair/Predsedavajući:

**Aleksandar Rodić, Institute Mihajlo Pupin, University of Belgrade, Serbia,**  
**Milica Petrović, University of Belgrade – Faculty of Mechanical Engineering, Serbia**

#### ROI1.1 WORKSPACE ANALYSIS OF A COLLABORATIVE BI-MANUAL INDUSTRIAL ROBOTIC SYSTEM

*Jovan Šumarac, "Mihailo Pupin" Institute, Serbia*

*Kosta Jovanović, School of Electrical Engineering, University of Belgrade, Serbia*

*Aleksandar Rodić, "Mihajlo Pupin" Institute, Serbia*

Bi-manual manipulation has been a focus of extensive academic research and has found its uses in industry as well. The workspace assessment of a robot is one of the key parameters in robot consideration for commercial purposes. As well, it is essential for the research of a bi-manual robotic system that often tends to replace humans in bi-manual tasks or directly share the workspace with humans. The goal of this paper is to present a detailed workspace analysis of a dual-arm collaborative robot. The dual-arm collaborative robot has been developed at the Robotics Laboratory at "Mihajlo Pupin" Institute and it is briefly presented in the paper. The workspaces of particular robot arms on the dual-arm system, a shared workspace for bimanual operation, and a manipulability analysis are presented. The simulations have been performed in Matlab, whereas CoppeliaSim robot simulator has been used for the visualization of the results. The presented results are an essential point in consideration of optimal trajectory planning and bi-manual collaborative robot control.

#### ROI1.2 INTERFACE DEVELOPMENT DEDICATED TO CONNECTING CAD TOOLS FOR 3D MODELING OF COMPLEX OBJECTS AND UR-5 INDUSTRIAL ROBOT'S CONTROLLER

*Uros Ilic, Faculty of Mechanical Engineering, University of Belgrade, Serbia*

*Jovan Sumarac, Institute Mihajlo Pupin, University of Belgrade, Serbia*

*Ilija Stevanovic, Institute Mihajlo Pupin, University of Belgrade, Serbia*

*Aleksandar Rodic, Institute Mihajlo Pupin, University of Belgrade, Serbia*

This article covers development of the interface dedicated to converting CAD models into some universal computer readable form. Main intention is transcription of complex models' geometry and coloring to numerical data base. At start the article will describe the process of saving CAD models in compatible form and its conversion to Microsoft Excel spreadsheets via set of MATLAB's designated scripts and functions. Main focus is forming a trajectory for UR-5 industrial robot, that will have laser pointer attached to its end-effector. As a verification of developed interface, laser pointer will follow the contour of the complex object's face that's lying on the work desk.

#### ROI1.3 A MOBILE ROBOT VISUAL PERCEPTION SYSTEM BASED ON DEEP LEARNING APPROACH

*Aleksandar Jokić, University of Belgrade – Faculty of Mechanical Engineering, Serbia*

*Lazar Đokić, University of Belgrade – Faculty of Mechanical Engineering, Serbia*

*Milica Petrović, University of Belgrade – Faculty of Mechanical Engineering, Serbia*

*Zoran Miljković, University of Belgrade – Faculty of Mechanical Engineering, Serbia*

In this paper, we present the novel mobile robot perception system based on a deep learning framework. The hardware subsystem consists of an Nvidia Jetson Nano development board integrated with two parallelly positioned Basler daA1600-60uc cameras, while the software subsystem is based on the convolutional neural networks utilized for semantic segmentation of the environment scene. A Fully

Convolutional neural Network (FCN) based on the ResNet18 backbone architecture is utilized to provide accurate information about machine tool models and background position in the image. FCN model is trained on our custom-developed dataset of a laboratory model of manufacturing environment and implemented on mobile robot RAICO (Robot with Artificial Intelligence based COgnition).

#### **ROI1.4 DEVELOPMENT OF APPLICATIVE INTERFACE FOR CONNECTING OPTICAL 3D SCANNER AND ROBOT CONTROLLER OF THE UR-5 INDUSTRIAL ROBOT ARM**

*Emilija Stanković, School of Electrical Engineering, University of Belgrade, Serbia*

*Ilija Stevanović, Institute Mihajlo Pupin, University of Belgrade., Serbia*

*Aleksandar Rodić, Institute Mihajlo Pupin, University of Belgrade., Serbia*

This paper is focused on the implementation, development and testing of an interface for connecting an automated 3D scanner and an industrial robot. Scanning is based on the use of Structured Light scanning software and the accompanying equipment. A rotating platform is constructed, and it is powered by an Arduino-controlled stepper motor. Program in addition to rotating platform by optimal number of degrees, also communicates with the scanning software - via the COM port to synchronize the movement of the rotating platform and the scan. 3D image is obtained by connecting several captured frames during the rotation of the object. The result is point cloud in space, post-processing is performed, and selected points form a robot trajectory. Simulation is performed by MATLAB Robotics Toolbox.

#### **ROI1.5 FUSION OF CAMERA-ACQUIRED DATA AND CAD 3D MODELS OF OBJECTS IN FORMING A VISUAL FEEDBACK LOOP FOR INDUSTRIAL ROBOTS**

*Miloš Nenadović, Faculty of Electrical Engineering, University of Belgrade, Serbia*

*Uroš Ilić, Faculty of Mechanical Engineering, University of Belgrade, Serbia*

*Aleksandar Rodić, Institute Mihajlo Pupin, Serbia*

In this paper, we present a computer vision system for object detection and spatial position and orientation recognition. To solve the problem, we separated the process in several stages: in the first stage the system uses principal component analysis (PCA) method in optimal conditions to detect objects in the image. Then, after the object is extracted, we projected it in the appropriate eigenspace, produced by singular value decomposition (SVD) of the set of images of the rotated 3D CAD model. The closest match is then processed by correlation between it and the real-object image in log-polar space. The result is combined with information from other cameras to derive the approximate position and object orientation using multiple-view geometry.

### **SESSION/SESIJA RO1+ROI2**

Friday/Petak, September/Septembar, 10<sup>th</sup>, 15:00 – 17:00, Room 1/Soba 1

#### **Chair/Predsedavajući:**

**Zoran Miljković, University of Belgrade – Faculty of Mechanical Engineering, Serbia,**

**Kosta Jovanović, University of Belgrade – School of Electrical Engineering, Serbia**

#### **RO1.1 ELEKTROTAKTILNI FEEDBACK ZA PREPOZNAVANJE OSOBINA PREDMETA MANIPULISANIH MEKIM ROBOTOM**

*Gorana Marković, School of Electrical Engineering, Tecnia Serbia Ltd, Serbia*

*Jovana Malešević, Tecnia Serbia Ltd, Serbia*

*Milica Isaković, Tecnia Serbia Ltd, Serbia*

*Miloš Kostić, Tecnia Serbia Ltd, Serbia*

*Matija Štrbac, Tecnia Serbia Ltd, Serbia*

*Kosta Jovanović, School of Electrical Engineering, Serbia*

Glavni preduslov da se u potpunosti iskoriste prednosti telemanipulacionih sistema jeste dvosmjerna razmjena haptičkih informacija između operatora i udaljene okoline, što omogućuje operatoru da percipira kolizije, kontaktne sile, težinu, oblik, veličinu, strukturu objekta i sl. Da bismo odgovorili na neke od ovih zahtjeva, u ovom radu predlažemo upotrebu elektrotaktilne stimulacije s prostornim i

frekvencijskim kodiranjem informacija. Korišćeni sistem sastoji se od robotskog aktuatora konačne mehaničke krutosti, električnog stimulatora i površinske elektrode s više polja (engl. multi-pad) koja se postavlja na vrh kažiprsta subjekta. Za razliku od sličnih postavki haptične povratne sprege, u našoj studiji ispitanici su se oslanjali isključivo na taktilne, bez vizuelnih ili auditivnih povratnih informacija. Eksperimentalni rezultati pokazali su da elektrotaktilna stimulacija može poslužiti za prenos informacija o mekoći (prosječna stope prepoznavanja 3 nivoa mekoće iznosila je 90%) i veličini (prosječna stopa prepoznavanja 2 veličine iznosila je 98%) predmeta koji se hvata udaljenim aktuatorom.

## **ROI.2 PRONALAZAK OPTIMIZACIONE FUNKCIJE KREANJA IZ SIMULIRANE DEMONSTRACIJE POKRETA ČUČNJA**

*Filip Becanovic, School of Electrical Engineering, University of Belgrade, Serbia*

*Vincent Bonnet, Laboratory for Analysis and Architecture of Systems, Toulouse, France*

*Samer Mohammed, Laboratory of Images, Signals and Intelligent Systems, Vitry sur Seine, France*

*Kosta Jovanović, School of Electrical Engineering, University of Belgrade, Serbia*

U ovom radu, posebno je uspostavljen pojednostavljeni ravanski biomehanički model čoveka za zadatak čučnja. Koristeći taj model, generišu se višestruki optimalni pokreti u odnosu na različite biomehaničke optimizacione funkcije i njihove linearne kombinacije. Iz optimalnih pokreta, optimizacione funkcije kojim su generisani pronalaze se pomoću inverzne optimizacije. Optimizaciona funkcija koja daje kvalitativno najsličnije kretanje ljudskom je kombinacija minimalnog zglobnog momenta, ubrzanja i snage. Međutim, čini se da stvarno ljudsko kretanje minimizira i neke optimizacione funkcije koje nisu razmatrane u ovom radu.

## **ROI2.1 INFLUENCE OF MUSCLE CO-CONTRACTION INDICATORS FOR DIFFERENT TASK CONDITIONS**

*Marija Radmilović, Institute Mihajlo Pupin, Serbia*

*Djordje Urukalo, Institute Mihajlo Pupin, Serbia*

*Milos Petrović, School of Electrical Engineering, University of Belgrade, Serbia*

*Filip Bečanović, School of Electrical Engineering, University of Belgrade, Serbia*

*Kosta Jovanović, School of Electrical Engineering, University of Belgrade, Serbia*

In this research paper, arm co-contraction indicators are examined in different scenarios such as load variation, hand velocity variation, and in tasks with different precision. The experimental results show the relationship between muscle co-contraction and increase of load, velocity, or precision. According to the results, the differences in the muscle co-contraction related with gender and the age of the participants for the same task are evident. The results of the analysis for each task are in the align with the results presented in the previous research. The results of this research have made a significant contribution in analyzing human stiffness and its implementation in the human-like motion of robots.

## **ROI2.2 DISTRIBUTION OF CONTROL TASKS TO SMART DEVICES IN INDUSTRIAL CONTROL SYSTEMS: A CASE STUDY**

*Zivana Jakovljevic, University of Belgrade - Faculty of Mechanical Engineering, Serbia*

*Dušan Nedeljković, University of Belgrade - Faculty of Mechanical Engineering, Serbia*

Cyber Physical Systems (CPS) and Internet of Things (IoT) open the way for new generation of Industrial Control Systems (ICS) characterized by high flexibility, modularity and reconfigurability necessary within Industry 4.0. Inevitable shift from centralized to distributed control systems is underway, but the changes are not as rapid as expected. One of the limiting factors is the lack of engineering techniques for distributed control systems design, simulation and verification. In this paper we analyze recently proposed techniques for distributed control systems development using an example of a simple transport system consisting of two CPS – smart conveyor belt and smart cylinder. In particular we consider the methods based on Control Interpreted Petri Nets (CIPN), Supervisory Control Theory (SCT) and IEC 61499 standard.



## ROI2.3 APPLICATION OF THE ANGULAR DEPENDENCY OF THE ZERO MOMENT POINT – INVITED PAPER

*Tilen Brečelj, Jožef Stefan Institute, Ljubljana, Slovenia*

*Tadej Petrič, Jožef Stefan Institute, Ljubljana, Slovenia*

In this paper the widely used stability parameter called the zero moment point (ZMP) is redefined as the angle around the center of mass (COM) of the investigated system. With this redefinition the ZMP is expressed in a more general way which enables its application in a wider range of situations. The angular definition of the ZMP was validated with motion measurements of a person performing different movements recorded with the OptiTrack camera system. The skeleton of the filmed person was reconstructed with the Motive software and a body model was used to reconstruct its COM, which was further used to calculate the ZMP. The stability analysis of the recorded motion measurements presented in this article shows on real-world examples of human motion that the angular redefinition of the ZMP provides a general, reliable and simple-to-apply way of determining the stability of a system.

# Telecommunications/ Telekomunikacije (TE)

## SESSION/SESIJA TEI1+TE1

Wednesday/Sreda, September/Septembar, 08<sup>th</sup>, 09:00 – 11:30, Room 2/Soba 2

### Chair/Predsedavajući:

**Nenad Milosevic, University of Nis, Faculty of Electronic Engineering, Serbia**

**Aleksandra Smiljanić, School of Electrical Engineering, University of Belgrade, Serbia**

### TEI1.1 ON THE IMPACT OF NETWORK LOAD ON CQI REPORTING AND LINK ADAPTATION IN LTE SYSTEMS

*Igor Tomic, Aspire Technology Unlimited, Serbia*

*Milutin Davidovic, Aspire Technology Unlimited, Serbia*

*Dejan Dragic, University of Belgrade - School of Electrical Engineering, Serbia*

*Predrag Ivanis, University of Belgrade - School of Electrical Engineering, Serbia*

Data payload in mobile networks is persistently increasing, which puts a lot of pressure to Mobile Operators to seek for solutions that will deliver cheaper bit per second. Network performance modelling is important discipline in process of technology strategy definition, evaluation of different solutions/scenarios and finally design and planning of Long Term Evolution (LTE) systems. One of the key prerequisites for successful performance modelling process and prediction of user experience with growing network load is to understand impact of traffic increase on link adaptation. In this paper correlation between network load, measured as Physical Resource Block (PRB) utilization, and Link adaptation, measured with reported Channel Quality Indicator (CQI) is analyzed. Analysis is done based on performance measurements from mature commercial LTE network with several frequency layers deployed. Impact of network load increase on link adaptation performance was assessed. Performance of different frequency bands were observed separately, analysis was conducted for low band (below 1 GHz) and mid band (in range between 1 GHz and 6 GHz). Furthermore, analysis was segmented for different topologies in terms of network density – from urban to rural. Finally, impact of user mobility and spatial distribution of terminals, variations during working days and weekends were investigated.

### TEI1.2 DESIGN PROBLEMS IN IMPLEMENTATION AND CONTROL OF MALICIOUS DRONE MISSIONS JAMMERS

*Jovan Radivojević, IRITEL a.d., Serbia*

*Aleksandar Vujić, IRITEL a.d., Serbia*

*Mladen Mileusnić, IRITEL a.d., Serbia*

*Predrag Petrović, IRITEL a.d., Serbia*

*Aleksandar Lebl, IRITEL, Serbia*

Three important problems related to the malicious drone missions jamming are analyzed in this paper. These problems are: 1) selection of drone signals which are going to be jammed and corresponding signal frequencies, 2) selection of optimum jamming strategies and definition of signal characteristics, and 3) design of reliable and user friendly system control mechanisms. The implemented solution allows jamming of a significant number of signals important for drone operation: video, telemetry and navigation signals. Classic sweeping is modified to multisweep jamming with continuous and discrete sub-bands to increase jamming efficiency. Device control is possible from the PC application software by the application of user friendly menus or from a specially designed module for remote control. The implemented jamming system is presented as well as the characteristics of the generated jamming signals.

### TEI1.3 PERFORMANCE DEGRADATION OF COHERENT DIRECT WIDEBAND LOCALIZATION DUE TO UNCERTAINTY IN RECEIVE ANTENNA POSITIONS

*Nenad Vukmirović, Inovacioni centar Elektrotehničkog fakulteta u Beogradu, Serbia*

*Miloš Janjić, Inovacioni centar Elektrotehničkog fakulteta u Beogradu, Serbia*

*Miljko Erić, Elektrotehnički fakultet Univerziteta u Beogradu, Serbia*

In the context of passive coherent direct localization by a distributed receiving antenna array, we analyze how much the localization error increases due to non-ideal knowledge of receive antenna positions. We perform Monte-Carlo simulations with a wideband localization algorithm for a large distributed antenna array that surrounds the area where the transmitters are, and for an array of two pairs of antennas facing the area from a side. The former exhibits a very low increase in localization error, whereas the latter increases the error significantly, compared to the effect of the noise. We also derive approximate confidence intervals to confirm the validity of the drawn conclusions.

### TEI1.4 COHERENT METHOD FOR RADIO-FREQUENCY MEASUREMENT OF DISTANCE BETWEEN ANTENNAS

*Nenad Vukmirović, Inovacioni centar Elektrotehničkog fakulteta u Beogradu, Serbia*

*Miloš Janjić, Inovacioni centar Elektrotehničkog fakulteta u Beogradu, Serbia*

*Nikola Basta, Elektrotehnički fakultet Univerziteta u Beogradu, Serbia*

*Miljko Eric, Elektrotehnički fakultet Univerziteta u Beogradu, Serbia*

The paper proposes a coherent method for radio-frequency measurement of the effective distance between two antennas. A transmitter sends a known waveform to a receiver, which processes the received signal to estimate its delay. The two transceivers are mutually synchronized, but different sources of delays/phase shifts still remain. A calibration step enables the system to estimate the total delay including the delays in the antennas. Differential measurements with three antennas enable us to estimate the delays in the antennas, which can be used as correction factors in measurements of the effective distance without the nuisance delays. The results of experiments performed on a prototype system, built of off-the-shelf equipment, show the consistency and the variance of the estimates. This method could be used to measure the geometry of a distributed array during its deployment, for the purposes of localization.

### TEI1.5 RESOLVABILITY OF TRANSMITTERS IN COHERENT DIRECT LOCALIZATION

*Nenad Vukmirović, Inovacioni centar Elektrotehničkog fakulteta u Beogradu, Serbia*

*Miloš Janjić, Inovacioni centar Elektrotehničkog fakulteta u Beogradu, Serbia*

*Miljko Eric, Elektrotehnički fakultet Univerziteta u Beogradu, Serbia*

Coherent direct localization promises high accuracies, that are especially useful for improving wireless link performance (the location-aided communication concept). The focus of the paper is to analyze the spatial resolution performance of three different localization algorithms in this category in the context of spectrum sensing -- i.e., their ability to successfully resolve multiple transmitters at different positions working in the same band and time interval. Namely, when two transmitters are close to each other, they interfere with the localization process, which can perceive them as a single source (and, therefore, fail to resolve them). We quantify the impact of this interference on the probability of resolution and the localization error for both cooperative and non-cooperative transmitters. The results of simulations show that, even when the distance between the transmitters is lower than the carrier wavelength, given that the inherent ambiguity problem allows, they can be resolved, with a localization error of a small fraction of the wavelength. The resolution rate is extremely high for the algorithm with a priori known waveform (for cooperative transmitters).

## TEI1.6 PERFORMANCE ANALYSIS OF LDPC AND POLAR CODES FOR MESSAGE TRANSMISSIONS OVER DIFFERENT CHANNEL MODELS

*Darija Čarapić, m:tel a.d. Banja Luka, Bosnia and Herzegovina*

*Mirjana Maksimovic, Faculty of Electrical Engineering, University of East Sarajevo, Bosnia and Herzegovina*

*Miodrag Forcan, Faculty of Electrical Engineering, University of East Sarajevo, Bosnia and Herzegovina*

The realization of a wireless communication system that will meet the demands of the modern world in terms of fast, secure, reliable, and cost-effective information exchange, is a challenging task. Having in mind that the transmission of data takes place in an imperfect channel environment where noise, fading, and interference are present, the achievement of timely communication with a minimum of errors during data transfer requires the right choice of the channel coding scheme. Channel coding is a fundamental component of the communication system and is intended to ensure that the information received is the same as the sent one. Two coding schemes are available in the fifth generation of mobile communications (5G): Low-Density Parity-Check (LDPC) codes for coding user information and Polar codes for coding control information. This paper presents a comparative simulation study of LDPC and Polar codes for message transmissions over different channel models (Additive White Gaussian Noise (AWGN), Rician, and Rayleigh). The Bit Error Rate (BER) performance of these codes was reviewed for all three channel models. The simulations considered variable message sizes and code rates for LDPC and Polar codes, different modulation patterns for LDPC codes, and different decoding schemes for Polar codes. The results of the simulations showed the performances of the LDPC and Polar codes in the case of channel models: AWGN with no fading and AWGN with fading. The LDPC codes have been superior in the case of long messages and the Polar codes have been more efficient in the case of short messages, hence justifying the use of both LDPC and Polar codes within the 5G.

## TEI.1 EKSPERIMENTALNA KARAKTERIZACIJA TURBULENCIJE U BEŽIČNOM OPTIČKOM KANALU

*Dejan Milic, Faculty of Electronic Engineering, University of Nis, Serbia*

*Jelena Anastasov, Faculty of Electronic Engineering, Serbia*

*Daniela Milovic, Faculty of electronic engineering, Serbia*

*Nenad Milosevic, Universty of Nis, Faculty of Electronic Engineering, Serbia*

U ovom radu prikazani su eksperimentalni rezultati dobijeni u laboratorijski kontrolisanim uslovima za karakterizaciju pojave turbulencije u slobodnom prostoru pri optičkom prenosu (FSO - free space optics). Prikupljeni podaci korišćeni su za statističku karakterizaciju funkcije gustine verovatnoće (pdf - probability density function) fluktuacija optičkog signala. U literaturi postoji niz empirijskih modela za različite režime turbulencije. Dobijeni pdf je upoređivan sa odabranim modelima iz literature u cilju definisanja statističkih osobina realnog turbulentnog kanala što je značajno za proračun performansi FSO sistema. Analiza je pokazala da se rezultati dobijeni pod datim eksperimentalnim uslovima dobro poklapaju sa eksponencijalno - Vejbulovim modelom turbulencije.

## TEI.2 PREGLED POSTOJEĆIH DPD MODELA SA OGRANIČENOM ŠIRINOM PROPUSNOG OPSEGA

*Tamara Muskatirovic-Zekic, ETF, RATEL, Serbia*

*Milan Cabarkapa, ETF, Serbia*

*Natasa Neskovic, ETF, Serbia*

*Djuradj Budimir, University of Westminster, United Kingdom*

Novi zahtevi za sve bržim i pouzdanijim servisima i uslugama putem mobilnih mreža dovode do potrebe za razvijanjem sofisticiranijih tehnika digitalne predistorzije (DPD) pojačavača (PA). Stoga je u ovom radu dat pregled postojećih DPD modela sa ograničenom širinom propusnog opsega (band-limited DPD). Ukratko su opisana predložena rešenja za band-limited DPD i data je njihova komparativna analiza. Takođe je izvedena i analiza kompleksnosti predloženih modela.

### TE1.3      SISTEM ZA DETEKCIJU I KLASIFIKACIJU NISKOLETEĆIH BESPILOTNIH VAZDUHOPLOVA – DRONOVA (SDKNBV)

*Mohammed Mokhtari, University of Defense in Belgrade, Military Academy, Serbia*

*Jovan Bajčetić, University of Defense in Belgrade, Military Academy, Serbia*

*Boban Sazdić-Jotić, University of Defense in Belgrade, Military Academy, Serbia*

Istraživanje predstavljeno u ovom radu prikazuje mogućnosti planiranog koncepta sistema za detekciju i klasifikaciju niskoletećih bespilotnih vazduhoplova (dronova) zasnovanom na metodama dubokog učenja. Cilj istraživanja predstavlja razvoj upotrebljivog sistema koji će u realnom vremenu vršiti detekciju i klasifikaciju dronova na bazi karakteristika njihovih radio emisija. Metode detekcije i klasifikacije primenjene u ovom istraživanju zasnivaju se na konvolucionoj neuronskoj mreži istreniranoj upotrebom formirane baze snimaka radio emisija sa nekoliko vrsta komercijalno dostupnih dronova. U početnoj fazi istraživanja predloženi sistem pokazuje verovatnoću detekcije i klasifikacije od 100 % za ukupno četiri nezavisne klase – nema drona, dron 1, dron 2 i dron 3 što predstavlja osnovu za dalji razvoj sistema za detaljniju klasifikaciju.

### TE1.4      EVALUACIJA DOMETA LORA IOT PRIMOPREDAJNIKA U URBANOM I RURALNOM OKRUŽENJU

*Dejan Milić, Univerzitet u Nišu, Elektronski fakultet, Serbia*

*Slavimir Stošović, Akademija tehničko-vaspitačkih strukovnih studija Niš, Serbia*

*Dejan Stevanović, Univerzitet u Nišu, Elektronski fakultet, Serbia*

*Jelena Anastasov, Univerzitet u Nišu, Elektronski fakultet, Serbia*

U ovom radu su prikazani praktični rezultati merenja nivoa signala prilikom prenosa podataka korišćenjem platforme tipa LoRa. Iako je ciljna primena ovakvih platformi na prvom mestu internet inteligentnih objekata u urbanim okruženjima, u radu je razmotrena i mogućnost njihove primene u ruralnim okruženjima. Jedna od ideja za primenu tehnologije jeste praćenje živog sveta u okruženjima koja se nalaze van naseljenih oblasti. Domet radio veze u ovakvom okruženju može biti znatno veći nego u urbanoj sredini, zavisno od uslova optičke vidljivosti i prepreka koje se nalaze na liniji između predajnika i prijemnika. Dobijeni rezultati pokazuju da se pri povoljnim uslovima zadovoljavajući rezultati prenosa mogu dobiti i na udaljenostima većim od 10 km.

# Artificial Intelligence/ Veštačka Inteligencija (VI)

## SESSION/SESIJA: VIII + VII

Wednesday/Sreda, September/Septembar, 08<sup>th</sup>, 17:15 – 18:45, Room 1/Soba 1

### Chair/Predsedavajući:

**Milan Milosavljević, Singidunum University, Belgrade, Serbia**

#### VIII.1 POTENTIAL OF USING SIMULATED DATA IN PROCESSING PHOTOACOUSTIC MEASUREMENT DATA

*Miroslava Jordovic Pavlovic, Western Serbia Academy of Applied Studies, Serbia*

*Aleksandar Kupusinac, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Slobodanka Galovic, Vinča Institute of Nuclear Sciences, Serbia*

*Dragan Markushev, Institute of Physics, University of Belgrade, Serbia*

*Mioljub Nešić, Vinča Institute of Nuclear Sciences, Serbia*

*Katarina Đorđević, Faculty of Physics, University of Belgrade, Serbia*

*Marica Popović, Vinča Institute of Nuclear Sciences, Serbia*

This paper explores the potential of using simulated data in calibration of photoacoustic measurement system. The database of simulated experimental values is created using software developed on the bases of the theory-mathematical model. Reliability of the data was gained thanks to the expert knowledge. An artificial neural network as a precise prediction tool is trained on the developed database of simulated data to recognize type of the microphone used as a detector in photoacoustic experiment. The result is classification model satisfies the basic requirements of a photoacoustic experiment: accuracy, reliability and real time operations. The paper discusses the optimization of classification model in terms of used computational power, required precision and process rate in relation with defined problem. The obtained results justify the idea of using simulated data in photoacoustic. Presented theory-mathematical model and classification model are part of developed machine learning framework for processing photoacoustic measurement data.

#### VIII.2 GENETIC ALGORITHM FOR BENT FUNCTIONS GENERATING

*Milan Stojanović, Faculty of Electronic Engineering, Serbia*

*Suzana Stojković, Faculty of Electronic Engineering, Serbia*

The importance of unique bent functions (most significantly in cryptography) creates a demand for their generation. Bent function generation is an interesting problem and, in this paper, we explore the idea of using invariant spectral operations in a Genetic algorithm for generating bent functions. Invariant spectral operations, when executed on bent function, resulting function is also bent. If multiple operations are performed consecutively, then there is a possibility that the newly generated bent function is not unique. A genetic algorithm is used to search the solution space in order to produce the most unique bent functions, for the least number of invariant spectral operations.

#### VIII.3 APPLICATION OF MACHINE LEARNING ALGORITHMS FOR CALCULATING AIR QUALITY INDEX

*Nebojša Bogdanović, University of Belgrade - School of Electrical Engineering (student), Serbia*

*Mladen Koprivica, University of Belgrade - School of Electrical Engineering, Serbia*

*Goran Markovic, University of Belgrade - School of Electrical Engineering, Serbia*

Air pollution is an ever-growing issue, especially severe in urban and industrial areas. Air Quality Index (AQI) is a unit of measuring the level of air pollution, which takes into account the concentrations of all relevant air pollutants. There are two main problems that must be addressed in AQI calculations, i.e. regression and classification. The regression problem consists of calculating (approximating) the AQI index based on the concentrations of different air pollutants. In classification problem, the measurements of air pollutants' concentrations are classified into different Air Quality Classes. In this paper a number

of Machine Learning (ML) and Deep Learning (DL) algorithms were designed and used in order to solve both the regression and classification problems for AQI. The main goal was to present performance comparison for wide set of ML and DL algorithms based on the values of Mean Absolute Error (MAE), Root Mean Squared Error (RMSE), Coefficient of Determination (R squared) in regression tasks, and Accuracy in classification tasks. Also, the percentage of algorithms' convergence and the time needed to perform these regression and classification tasks are also measured.

#### VIII.1.4 HUMAN ACTIVITY DETECTION USING MACHINE LEARNING AND BRACELET WITH BLUETOOTH TRANSMITTER

*Stevan Cakic, University of Donja Gorica, Montenegro*

*Tomo Popovic, University of Donja Gorica, Montenegro*

*Srdjan Krco, DunavNET, Serbia*

*Daliborka Nedic, DunavNET, Serbia*

*Stevan Sandi, University of Donja Gorica, Montenegro*

The use of artificial intelligence and machine learning is finding its purpose in various fields nowadays. This paper describes a study in which Internet of Things and machine learning are used to implement human activity detection based on data collected from bracelet equipped with Bluetooth transmitter. The main focus of the study was development of a prediction model using deep learning that would help elderly people and their caretakers. Time series data about elderly persons' activity was collected from bracelet using a Bluetooth gateway and IoT platform, and later annotated based on the activity logs they kept in a form of diary. A neural network is trained to classify data into two groups corresponding to activity of the person wearing the bracelet. Initial study shows promising results of the presented approach for the use in human activity detection for elderly.

#### VII.1 REŠAVANJE PROBLEMA EKONOMIČNE RASPODELE SNAGA GENERATORA PRIMENOM FAZORSKE OPTIMIZACIJE ROJA ČESTICA

*Milena Jevtić, Technical Faculty in Bor, University of Belgrade, Serbia*

*Miroljub Jevtić, Faculty of Technical Sciences in Kosovska Mitrovica, University of Priština, Serbia*

*Jordan Radosavljević, Faculty of Technical Sciences in Kosovska Mitrovica, University of Priština, Serbia*

*Sanela Arsić, Technical Faculty in Bor, University of Belgrade, Serbia*

*Dardan Klimenta, Faculty of Technical Sciences in Kosovska Mitrovica, University of Priština, Serbia*

Minimizacija troškova goriva i emisije štetnih gasova u termoelektranama podešavanjem izlaznih snaga generatora je jedan od važnih problema u upravljanju elektroenergetskim sistemima. Ovaj problem je poznat kao Combined economic emission dispatch (CEED) problem. U ovom radu je za rešavanje CEED problema predložen meta-heuristički algoritam pod nazivom Fazorska optimizacija roja čestica, koji predstavlja unapređenu varijantu Optimizacije roja čestica. Parametri Fazorske optimizacije roja čestica se tokom iteracija automatski podešavaju pa je ovaj algoritam, adaptivni i neparametarski, što je njegova prednost. Performanse predloženog algoritma za rešavanje CEED problema se u radu ocenjuju na standardnom IEEE test sistemu sa 30 čvorova i 6 generatora. Na osnovu dobijenih rezultata utvrđeno je da ovaj algoritam ima bolje karakteristike od algoritama koji su primenjeni u drugim publikovanim radovima za rešavanje CEED problema.

## **Metrology/ Metrologija (ML)**

### **SPECIAL SESSION: STOCHASTIC METHODS IN MEASUREMENT/ SPECIJALNA SESIJA: STOHAŠTIČKE METODE U MERENJIMA SS-ML1**

Wednesday/Sreda, September/Septembar, 08<sup>th</sup>, 09:00 – 11:30, Room 3/Soba 3

#### **Chair/Predsedavajući:**

**Vladimir Vujicic, Faculty of Technical Sciences, University of Novi Sad, Serbia**

#### **SS-ML1.1 MERENJE SNAGE I ENERGIJE VETRA ANEMOMETROM BEZ POKRETNIH DELOVA**

*Boris Ličina, Univerzitet Privredna akademija Novi Sad, MEF - Beograd, Serbia*

*Bojan Vujičić, University of Novi Sad, Serbia*

*Platon Sovilj, University of Novi Sad, Serbia*

*Vladimir Vujicic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

U radu se analizira merenje snage i energije vetra anemometrom sa nepokretnim ramovima. Razmatraju se dva scenarija – merenje standardnom sampling metodom (SSM) i merenje dvobitnom stohastičkom digitalnom mernom metodom (SDMM). Novina je softversko diterovanje izlaza iz anemometra.

#### **SS-ML1.2 INŽENJERSKA INDUKCIJA – PREDLOG DEFINICIJE I JEDNA POTVRDA PREDLOGA**

*Bojan Vujičić, University of Novi Sad, Serbia*

*Boris Ličina, Univerzitet Privredna akademija Novi Sad, MEF - Beograd, Serbia*

*Platon Sovilj, University of Novi Sad, Serbia*

*Vladimir Vujicic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

U radu se predlaže definicija novog inženjerskog pojma nazvanog inženjerska indukcija. Predlog je primenjen u istraživanjima optimalne strukture uređaja za merenje snage i energije vetra i pokazao je svoju efikasnost i primenljivost.

#### **SS-ML1.3 PREGLED DOKTORATA U KOJIMA JE ISTRAŽIVANA STOHAŠTIČKA MERN METODA**

*Dragan Pejić, Fakultet tehničkih nauka, Serbia*

*Vladimir Vujicic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

U radu je prikazan razvoj ideja vezanih za stohastičku adicijonu analogno-digitalnu konverziju. Pregled je dat kroz prizmu doprinosa 18 doktorskih radova, počev od 1996. kada je odbranjen prvi doktorat na ovu temu. Neki radovi su u većoj meri bili teorijskog značaja, drugi su imali značajniju praktičnu težinu, ali su svi dali doprinos u razvoju i primeni stohastičke konverzije u poslednjih četvrt veka.

#### **SS-ML1.4 PRIMENA MERNOG INSTRUMENTA VMP-20 ZA MERENJE SNAGE U KOLU NAIZMENIČNE STRUJE**

*Nemanja Vidović, Elektrotehnička škola "Mihajlo Pupin" Novi Sad, Serbia*

*Isidora Sabadoš, Elektrotehnička škola "Mihajlo Pupin" Novi Sad, Serbia*

*Atila Juhas, Fakultet tehničkih nauka, Novi Sad, Serbia*

*Saša Skoko, Elektrotehnička škola "Mihajlo Pupin", Novi Sad, Serbia*

U ovom radu predstavljen je jedan način primene mernog instrumenta MVP20 u izvođenju laboratorijskih vežbi iz predmeta Električna merenja. Tema rada je merenje snage u kolu jednofazne struje za različite vrste opterećenja, predstavljanje rezultata merenja kao i mogućnost praktičnog izvođenja laboratorijske vežbe u realnom vremenu. Pažljivom organizacijom laboratorijskih vežbi, kao



što je prikazano u ovom radu, moguće je uspostaviti maksimalnu korelaciju između osnovne teorije električnih merenja, mernih metoda kao i drugih stručnih predmeta kao što su Osnove elektrotehnike i teorija naizmeničnih struja.

#### SS-ML1.5 PRIMENA MERNOG INSTRUMENTA MVP-20 ZA IZVOĐENJE LABORATORIJSKE VEŽBE - POPRAVKA FAKTORA SNAGE

*Isidora Sabadoš, Elektrotehnička škola "Mihajlo Pupin" Novi Sad, Serbia*

*Nemanja Vidović, Elektrotehnička škola "Mihajlo Pupin" Novi Sad, Serbia*

*Atila Juhas, Fakultet tehničkih nauka, Novi sad, Serbia*

*Saša Skoko, Elektrotehnička škola "Mihajlo Pupin" Novi Sad, Serbia*

U ovom radu predstavljen je jedan način primene mernog instrumenta MVP20 u izvođenju laboratorijskih vežbi iz predmeta Električna merenja. Tema rada je popravka faktora snage u jednofaznom sistemu napajanja. Radom je obuhvaćen osnovni teorijski principi kompenzacije reaktivne snage i dat je prikaz izvođenja laboratorijske vežbe. Primena instrumenta MVP20 i odgovarajućeg softvera VMPCalc ima posebnu pogodnost u organizaciji laboratorijskih vežbi na daljinu- online, što je u radu posebno naznačeno.

#### SS-ML1.6 ALGORITAM GENERISANJA DVOBITNIH DITEROVANIH FURIJEVIH BAZISNIH FUNKCIJA

*Jelena Đorđević Kozarov, Elektronski fakultet, Univerzitet u Nišu, Niš, Serbia*

*Atila Juhas, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Serbia*

*Platon Sovilj, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Serbia*

*Vladimir Vujičić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Serbia*

U radu je definisan algoritam generisanja dvobitnih diterovanih Furijeovih bazisnih funkcija (DDFBBF) koje se koriste u SDDFT procesoru. Teorijski i eksperimentalno je potvrđena njihova ortonormiranost što je prikazano u radu.

#### SS-ML1.7 OPTIMALNA REZOLUCIJA STOHAISTIČKIH EMBEDID SISTEMA

*Dragan Pejić, Fakultet tehničkih nauka, Serbia*

*Aleksandar Radonjic, Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Serbia*

*Vladimir Vujicic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

U radu se elaborira primena stohastičke digitalne merne metode (SDMM) u embedid sistemima. U literaturi je dokazano da je optimalna rezolucija SDMM trobitna i da je optimalni brojni sistem za primenu u obradi takođe trobitni. Ove činjenice su motivisale autore da analiziraju optimalne rezolucije stohastičke A/D konverzije, stohastičke obrade i stohastičke D/A konverzije.

#### SS-ML1.8 ИДЕЈНИ ПРОЈЕКАТ ГЕНЕРАТОРА АНАЛОГНОГ ДИСКРЕТНОГ УНИФОРМНОГ ШУМА

*Bojan Vujicic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Aleksandar Radonjic, Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Serbia*

*Dragan Pejić, Fakultet tehničkih nauka, Serbia*

*Vladimir Vujicic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

У раду се предлаже идеја генератора аналогног дискретног униформног шума (ГАДУШ) за примену у стохастичкој дигиталној мерној методи. Предложеним решењем, за разлику од стандардног, које користи генератор случајних бројева и прецизни и тачни дигитално-аналогни конвертор (ДАК), се превазилази проблем ограничене резолуције ДАК-а и његов узак пропусни опсег.

## SS-ML1.9 PRIMER DALJINSKOG MERENJA SINUSOIDALNIH SIGNALA INSTRUMENTOM VMP20

*Jovan Ničković, ETŠ "Nikola Tesla", Niš, Serbia*

*Jelena Đorđević Kozarov, Elektronski fakultet, Univerzitet u Nišu, Niš, Serbia*

*Radoje Jevtić, ETŠ "Nikola Tesla", Aleksandra Medvedeva 18, 18000 Niš, Serbia*

*Atila Juhas, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Serbia*

Monofazni analizator snage VMP20 koristi se za realizaciju nastave u Laboratoriji za elektroenergetiku u ETŠ „Nikola Tesla“ u Nišu. U radu je prikazana realizacija laboratorijske vežbe, koja se izvodi u okviru predmeta Merenja u elektroenergetici. Dobijeni rezultati su prikazani tabelarno. U radu se, takođe, opisuje i daljinsko merenje sinusoidalnih signala u ED mreži korišćenjem VMP20 monofaznog analizatora snage. Demonstracija on-line prikaza mrežnog napona i frekvencije realizovana je na samoj konferenciji.

















Date / Датум	September 8th / 8. Септембар			September 9th / 9. Септембар			September 10th / 10. Септембар	
Time / Време	Room/Соба 1	Room/Соба 2	Room/Соба 3	Room/Соба 1	Room/Соба 2	Room/Соба 3	Room/Соба 1	Room/Соба 2
9:00 – 11:30	AKI1+AK1(9)	TEI1+TE1(10)	Stochastic methods in measurement / Стохастичке методе у мерењима	RTI1(9)	ML1 (8)	NTI1+NT1(5)	BTI1(8) +IP/ПТ3+IP/ПТ5	NMI1+NMI1(9) +IP/ПТ4
11:30 – 11:45	Coffee break / Пауза за кафу							
11:45 – 12:30	Digital Serbia and Republic of Srpska / Дигитална Србија и Република Српска			What computers can't do today / Шта рачунари не могу данас?			Power engineering in the XXI century / Електроенергетика у XXI веку	
12:45 – 13:30	Opening Ceremony / Отварање ЕТРАН/ІСТРАН 2021 Cocktail/Коктел			In memoriam – Нинослав Стојадиновић				
13:30 – 15:00	Free time for lunch or for a walk / Слободно време за ручак или шетњу							
15:00 – 17:00	MTI(5)+AP+AP(3)	AUI1(6) +IP/ПТ1	EK1+EK1(2)+MO1(5)	RTI2(8)	ML2 (6) +IP/ПТ2	ELI1(7)	ROI1(5)	EEl1(4)
17:00 – 17:15	Coffee break / Пауза за кафу							
17:15 – 18:45	VII1+VI1(5)	AUI1(4)	MO1(4)	RTI1(5)			ROI1+ROI2(5) +IP/ПТ6	EEl1(6)
18:45 – 19:30	In memoriam – Милољуб (Мића) Смиљанић			General Assembly of ЕТРАН Society/ Скупштина друштва за ЕТРАН				
20:00 – 22:00				Conference official dinner / Званична вечера				

List of invited lecturers / Листа позваних предавача

IP/ПТ1: Prof. Rachid Maiti, Bordeaux, France, <http://maiti.fr/>  
IP/ПТ2: Dr. Branislav Dokic, Ottawa, Canada, <https://ieeexplore.ieee.org/author/37350041800>  
IP/ПТ3: Prof. Strahinja Došen, Aalborg, Denmark, <https://vbn.aau.dk/en/persons/113479>  
IP/ПТ4: Dr. Valentin Ivanovski, Belgrade Serbia, <http://www.advancedmaterialsgroup.edu.rs/valentin-ivanovski/>  
IP/ПТ5: Nenad Jovčić, University of Belgrade, Serbia, <https://www.etf.bg.ac.rs/en/faculty/staff/nenad-jovcic-1495#gsc.tab=c>  
IE/ПТ6: Dr Tadej Petrič, Dept.of Automation Biocybernetics and Robotics Jozef Stefan Institute, Ljubljana, Slovenia, <http://cobotat.jijs.si/members/tadej-petric/>